RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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RADIOLOGY

A MONTHLY PUBLICATION DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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Vol. 51 DECEMBER 1948 No. 6

The Role of Irradiation in the Management of Carcinoma of the Breast[1]

EUGENE P. PENDERGRASS, M.D., and DAVID KIRSH, Ph.D., M.D.[2]

IN PREVIOUS COMMUNICATIONS (7, 8) a survey was made of 387 cases of carcinoma of the breast seen in the Radiologic Clinic of the Hospital of the University of Pennsylvania from 1902 to 1931. The present report brings this material up to date by inclusion of all cases seen from 1932 through 1939. In the earlier paper the opinion was expressed that the data did not demonstrate any evidence of superiority of combined operation and postoperative irradiation over surgery alone in the treatment of these cases. Since 1936 routine postoperative x-ray therapy for carcinoma of the breast has been abandoned, and the present data include a five-year follow-up on a number of cases treated by surgery alone.

MATERIAL

The records of 387 cases of carcinoma of the breast seen from 1902 to 1931 were considered adequate for inclusion in the earlier studies. From 1932 to 1939, 445 patients were seen for the same reason, and the records of 406 are included in this study. The remaining 39 records were discarded because the patient was seen only in consultation or was lost track of in less than six months. The cases now reported are compared with reports of the previous cases, and do not represent a continuous study.

CLASSIFICATION

The material has been classified according to Steinthal's plan (11), which separates patients into three clinical groups:

Group I: Those having a tumor, apparently growing very slowly, and measuring only a few centimeters in diameter, entirely confined to the mammary gland; the skin is not yet attached; the axillary nodes are few in number and are first discerned only at operation.

Group II: Those with definitely growing tumors which, after remaining stationary for some time, begin to increase in size; the skin becomes adherent and nodes in the axilla are definitely demonstrable.

Group III: Those in whom a large part of the mammary gland has become involved, the tumor has invaded the skin and underlying structures; frequently the supraclavicular nodes are also involved.

Group Unknown: It has been necessary to include this classification to account for those patients in whom the data concerning the original physical findings were either lacking or incomplete.

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The above classification is exceedingly difficult to follow and is therefore unsatisfactory. In the future we plan to follow the classification developed by Portmann (9). It was not used in the present study because, first, we were unaware of its existence until all of our data were collected, and, in the second place, we were anxious to compare the present data with our two previous reports (7, 8). Portmann's method is logical, combining as it does the clinical and histologic features. It would seem that analyses of data included in such a classification would serve to reveal the true answer to the role of irradiation in the management of carcinoma of the breast.

A CLASSIFICATION FOR CASES OF PRIMARY CARCINOMA OF THE BREAST BASED ON CLINICAL AND PATHOLOGIC CRITERIA

U. V. Portmann (9)

Group or Stage I
Skin: Not involved.
Tumor: Localized in breast and movable.
Metastases: None in axillary lymph nodes or elsewhere.

Group or Stage II
Skin: Not involved.
Tumor: Localized in breast and movable.
Metastases: Few axillary lymph nodes involved; no metastases elsewhere.

Group or Stage III
Skin: Edematous; brawny red induration or inflammation not obviously due to infection; extensive ulceration. Multiple secondary nodules.
Tumor: Diffusely infiltrating breast; fixation of tumor to chest wall; edema of breast; secondary tumors.
Metastases: Many axillary lymph nodes involved or fixed; no clinical or roentgenologic evidence of remote metastasis.

Group or Stage IV
Skin: As in any other group or stage.
Tumor: As in any other group or stage.
Metastases: Axillary and supraclavicular lymph nodes extensively involved: clinical or roentgenologic evidence of more remote metastasis.

Portmann (9) states that, when this classification was applied to their series of cases, it was found that patients with certain clinical manifestations of extensive involvement, placing them in Group III or IV, were not curable. These manifestations have been arranged in simplest form as the "Criteria of Incurability" as follows:

CRITERIA OF INCURABLE CARCINOMA OF THE BREAST (9)

The Skin
1. Edema (orange or pig skin) of more than slight extent.
2. Ulceration of more than slight extent.
3. Brawny red and inflamed, not obviously due to infection.
4. Multiple secondary nodules.

The Breast
1. Diffusely edematous.
2. Diffusely infiltrated.
3. Multiple secondary tumors.
4. Fixation to chest wall.

Metastases
1. Axillary lymph nodes numerous, extensively involved, or fixed.
2. Supraclavicular lymph nodes or edema of arm.
3. Involvement of contralateral breast or lymph nodes.
4. Remote metastases in bones, lungs, or other viscera.

Portmann (9) feels that his classification and the criteria of incurability allow one to analyze a series of cases, compare the results of operation alone and with postoperative roentgen therapy, and also to illustrate the indications and limitations of these two therapeutic procedures.

DEFINITION OF TERMS WITH COMMENTS ON VARIOUS TYPES OF IRRADIATION

Operability and Inoperability: What constitutes an operable lesion is a moot question. The criteria set forth by Haagensen and Stout (4) are recommended as of great practical value. In order for physicians to be able to evaluate any method or methods of therapy, it is necessary to employ the same criteria in reporting cases.

Radical Resection: Mastectomy including the axillary contents, with removal of the pectoral muscles and fascia. In only a few patients having this type of operation was there failure to remove the pectoral muscles.

Simple Resection: Removal of the breast only.

Preoperative Irradiation: Administration of radiation prior to operation, as a thera-

peutic procedure, to the involved breast and ipsilateral axilla, in cases in which the lesion is considered operable.

A factor that seems to be important concerns the time interval between the irradiation and the operation. Many patients are operated upon immediately following irradiation; in some cases operation is delayed for ten days to three weeks, and there are surgeons who prefer to wait for two or three months before operating in order for the acute phase of the x-ray reaction to subside and the effects of the radiation on the lesion and the surrounding tissues to become manifest.

The factors used in delivering the radiation are extremely important. Unless more attention is paid to this, the true concept of the influence of radiation may never be attained. There must be so much individualization in applying roentgen or radium therapy, that one will find it difficult to evaluate results even under ideal circumstances.

Radiation given elsewhere than to the tumor-bearing region is regarded as *prophylactic*, provided there is no evidence of metastasis.

Postoperative Irradiation: Cases receiving postoperative irradiation may be divided into several groups. The *first* group includes those cases in which radiation is directed over the operative field in patients regarded as having operable lesions and where the operative and pathological findings suggest that complete removal has been effected. The *second* group includes those cases in which radiation is directed over the operative field in patients with lesions that before operation were thought to be operable but after operation were regarded as inoperable, but in whom an effort was made to remove every possible vestige of the growth. A *third* group would include those cases in which radiation is directed over the operative field and axilla on the affected side in patients who have had a simple mastectomy or simple mastectomy plus an incomplete axillary dissection.

Here again it is necessary to be concerned as to the time interval between operation and postoperative radiation. In some instances, radiation is directed into the open wound before the skin flaps are closed; some surgeons have their patients irradiated after completion of the operation; in still others irradiation is delayed for varying intervals, one week, two weeks to a month, six weeks to three months, etc.

It seems obvious that we cannot (assuming that the types of carcinoma and the reactive responses of the patient were identical) compare the results of postoperative irradiation if we do not concern ourselves with such details. It is extremely important for us to know whether surgical shock decreases favorable reactive responses of a patient to radiation. Likewise, we are interested in knowing whether radiation directed over an operative field, shortly after operation, enhances or interferes with normal physiological repair. Does one obtain maximum beneficial x-ray effect during the period of physiological repair or later?

The factors and methods of irradiation have to be known for each case in order to attempt an evaluation of such a procedure.

Prophylactic Irradiation: This term is reserved for radiation directed over lymphatic drainage areas from an operable carcinoma of the breast—and in some instances an inoperable lesion—in which there is no evidence of metastasis. The drainage areas frequently included are the mediastinum, the lung fields, the opposite breast and axilla, the supraclavicular fossae, and the epigastrium.

Combination or Mixed Irradiation: Any of the above types of irradiation may be combined, *i.e.:*

Pre- and postoperative irradiation.
Preoperative, postoperative, and prophylactic irradiation.
Postoperative and prophylactic irradiation.

Irradiation for Operable Carcinoma: This is reserved for those cases in which surgery is contraindicated or refused.

Irradiation for Inoperable Carcinoma: It is extremely important that the patients

under this heading be carefully studied and followed. They fall into two general groups: (*a*) those who respond so well to irradiation that subsequently a simple mastectomy is performed for palliative reasons and (*b*) those who never have any treatment except irradiation.

Irradiation for Inflammatory Carcinoma: These lesions are regarded as inoperable.

Recurrences and Metastases: Under this heading there are several classifications:

(*a*) *Operable Recurrences:* On the basis of our experience it is difficult to define an operable recurrence. Many lives will be saved if radical surgery is available.

(*b*) *Inoperable Recurrences:* Irradiation, hormonal therapy, or chemotherapy is essential.

(*c*) *Operable Metastases:* Operable metastases include those that are distant from the primary lesion and should be classed separately from recurrences. They probably respond differently because oftentimes the metastases in lymph channels and lymph nodes do not react to radiation in the same way as do recurrences.

(*d*) *Inoperable Metastases:* Irradiation, hormonal therapy, or chemotherapy is recommended. The radiologist and the internist have much to learn in the handling of inoperable metastases. If we are as meticulous in our records of these cases as the cardiologist is in the case of a decompensating heart or the clinician in the direction of a case of nephrosis, we believe more can be accomplished.

(*e*) *Bone Metastases.* Skeletal metastases should be classed separately from other metastases, because the immediate results from irradiation are beneficial in a great many instances. There may be inherent in bone a factor which is partly responsible for the good effects. If more could be learned about this factor, we might improve the treatment of metastases elsewhere.

IRRADIATION TECHNIC

In general, the technic used during different periods since 1902 has been relatively uniform, as treatment was given under the direction of Dr. Henry K. Pancoast and one of the authors. As might be expected, there has been certain individualization, especially in the group treated for recurrences or metastases. While we encountered wide variations in the number of treatment cycles, no cases were included that had not received at least one complete series of treatment. Although the majority of patients were treated with roentgen rays cross-fired into the breast, the radium pack and interstitial radium were used in many instances.

The methods for giving roentgen therapy have changed considerably since 1902. Because of this, we have separated the various technics as used during different periods.

1902–16: 115 kv.; 5 ma.; 25 cm. target-skin distance; filtration, 3 mm. aluminum + 1 mm. glass (with these settings a dose of about 55 r per minute, measured in air, was obtained); portals 5 × 5 cm. Approximately 20 portals were used in each patient, though in some cases the number was as high as 40. Patients were treated daily, receiving about 600 r, measured in air, to each of 6 to 8 portals until the entire area had been treated once. This series was repeated, on an average, six times in each patient at intervals of two to three months. In some patients, these treatments were supplemented by topical application of a radium pack containing 200 mg. of radium filtered through 5 mm. aluminum + 1 mm. rubber, at 0.5 cm. distance. The radium pack was allowed to stay in place for twenty minutes over 4 to 6 portals.

1917–21: 125 kv.; 5 ma.; 25 cm. target-skin distance; filtration, 1 mm. glass + 3 mm. aluminum + 7/8 inch wood (with these settings a dose of about 60 r per minute, measured in air, was estimated); portals, 5 × 5 cm., 10 × 10 cm. Approximately 22 portals were used in each patient. Patients were treated daily, receiving about 600 r, measured in air, to each of several portals until the entire area had been treated once. This series was repeated, on an average, five times during a period of eight months. With the exception of 1.5

mm. brass + 1 mm. rubber filtration, use of the radium pack remained unchanged.

1922–26: 135 kv.; 5 ma.; 25 cm. target-skin distance; filtration, 1 mm. glass + 3 mm. aluminum + 7/8 inch wood (with these settings a dose of about 75 r per minute, measured in air, was obtained); portals, 10 × 10 cm., 15 × 15 cm. Approximately 10 portals were used in each patient. Patients were treated daily, receiving about 600 r, measured in air, to each of 2 portals until the entire area had been treated once. This series was repeated, on an average, three times during a period of six months. In this 1922–26 period, a 200-kv. apparatus was obtained and was used, as a rule, for treating metastases. In some patients, these treatments were supplemented by topical application of a radium pack, according to the technic described for 1917–21.

1927–31: The technic employed during this period was practically the same as that used during the five years preceding, but there was a tendency to increase the number of series given, the average number being four covering about nine months. In addition, radium was filtered through 3 mm. brass + 3 mm. rubber. Here again, multiple small portals were used, each area receiving approximately 1 skin erythema dose. During this period, interstitial radium was used extensively in the form of the emanation and the element.

1932–36: 135 kv.; 5 ma.; 30 to 40 cm. target-skin distance; filtration, 5 mm. aluminum or 0.25 mm. copper + 1 mm. aluminum (with these settings, about 40 to 50 r per minute, measured in air, was obtained); portals, 15 × 15 cm., 20 × 20 cm. Approximately 10 portals were used in each patient. The patients were treated daily, receiving about 300 r, measured in air, to each of 2 to 4 portals. This dose was repeated until each area received approximately 600 r, which constituted one series. These series were repeated every two to three months until two or three such series had been delivered. The methods for the use of radium compare with those outlined in the 1927–31 period. High-voltage radiation was primarily used for metastases.

The preoperative technic employed during each period was very much like the postoperative technic. Instead of irradiating the healthy side, numerous additional portals were used for cross-firing into the breast. During 1934–36, all preoperative treatment was given with 200 kv.; 15 ma.; 0.5 mm. copper + 2 mm. aluminum, h.v.l. 1.10 mm. copper, at 18 to 50 cm. target-skin distance, with portals varying in size from 20 to 130 sq. cm. The fractional method was used, each portal being treated up to skin tolerance. This, as a rule, was reached at 2,000 to 2,400 r, measured in air. This produced a very marked reaction, which readily subsided, and was followed by surgery in about six to eight weeks.

1937–39: Irradiation was employed only for inoperable recurrent or inoperable metastatic disease. We have not employed postoperative and prophylactic irradiation during this period.

DATA

Of the 406 cases included in the present survey, 350 were subjected to surgery and 56 were treated by irradiation alone—the latter treatment being used because the lesion was considered inoperable, surgery was refused by the patient, or there was some medical contraindication. Two-hundred and five of the cases were operated upon by the surgeons of the Hospital of the University of Pennsylvania, and 145 or 41 per cent were operated upon elsewhere and came under our care subsequently. Of the cases subjected to surgery, 188 received postoperative roentgen irradiation to the operative site and lymph node areas, while 162 received no irradiation except when metastatic or recurrent disease developed.

One-hundred and forty-one private patients came to a physician an average of 7.4 months after the apparent onset of the disease, while 127 ward patients came 9.3 months after the onset. Twenty Negro patients took an average of twelve months before seeking medical care.

TABLE I: INCIDENCE OF FIVE-YEAR SURVIVALS IN SUCCESSIVE PERIODS

	Ratio of Number in Group I to Number in Other Groups	Total Cases	Five-Year Survivals
1902–16	?	24	9 (38%)
1917–21	1:30	89	22 (25%)
1922–26	1:16	131	35 (26%)
1927–31	1:6	143	35 (24%)
1932–39	1:6	350	147 (42%)

Twenty-eight patients (7 per cent) gave a history of previous trauma to the breast, while 40 (10 per cent) gave a history of previous breast disease, such as sore nipples, caked breast, mastitis, fibroadenoma, abscess, etc.

The end-results are expressed in terms of five-year survivals calculated from the date of operation. Where possible, comparison has been made of the results obtained in various chronologic periods, or the data has been combined to give a survey covering all cases seen in the thirty-eight-year period. However, no effort was made to secure additional follow-up on cases seen prior to 1932. The end-results in successive periods have been tabulated in Table I. From the data one can conclude that a constant survival rate held from 1902 to 1931, the apparent superiority of the 1902–16 period not being statistically significant due to the small number of cases. The increase in the survival rate from 26 per cent in the early period to 42 per cent in the latest period is, however, significant. This would imply either that our methods of treatment, both surgical and radiological, have improved, that our patients are being seen with earlier lesions, or that better selection of cases suitable for operative care is being exercised. Cancer education of the public, better defined criteria of operability (4), and the use of preoperative chest and bone surveys in detecting metastatic disease all have had a role in the apparent improvement noted.

Five-year survivals in the various clinical groups are shown in Table II. It will be noted that the distribution of the cases in the various groups differs. Since the cases in the two chronologic periods were classified by two different investigators, this difference emphasizes the importance of the personal equation in any method of clinical classification. In the 1902–31 period, the difference in survival rate between Groups I and II was not significant, while that between Groups II and III was significant. In the 1932–39 period significant differences were observed between all groups, the survival ranging from 75 per cent in Group I to 23 per cent in Group III. If one compares each group in the two chronologic periods a significant improvement in survival is observed in all cases for the latter period.

TABLE II: FIVE-YEAR SURVIVALS GROUPED ACCORDING TO STEINTHAL'S CLASSIFICATION

	Total Number of Cases	Five-Year Survivals	Percentage of Five-Year Survivals
Group I			
1902–31	34	17	50
1932–39	51	38	75
Group II			
1902–31	35	13	37
1932–39	102	52	51
Group III			
1902–31	182	28	15
1932–39	112	26	23
Unknown			
1902–31	136	43	31
1932–39	85	31	36
TOTAL			
1902–31	387	101	26
1932–39	350	147	42

TABLE III: SURVIVAL RATE IN VARIOUS AGE GROUPS OF OPERATED CASES

Age	20–29	30–39	40–49	50–59	60–69	70–79	Total
Total Number of Cases	8	51	107	101	64	19	350
Five-Year Survivals	3	19	52	38	24	11	147
Per Cent Five-Year Survivals	38	37	49	38	38	58	42

The survival rate in operated cases in various age groups is presented in Table III. The Chi square test, performed by Dr. E. Douglass Burdick,[3] indicated no

[3] The authors are indebted to E. Douglass Burdick, Ph.D., statistician of the University of Pennsylvania, for subjecting all the data in this paper to statistical analysis.

TABLE IV: DEATHS ATTRIBUTABLE TO CARCINOMA IN VARIOUS AGE GROUPS

Age	20–29	30–39	40–49	50–59	60–69	70–79	Total
Number of Patients Alive	3	19	52	38	24	11	147
Number of Patients Dead	5	32	55	63	40	8	203
Number of Deaths Attributable to Age*	0	1	3	7	10	7	28
Number of Deaths Attributable to Carcinoma	5	31	52	56	30	1	175
Percentage of Deaths Attributable to Carcinoma	100	97	95	89	74	12	86

* These figures do not exclude deaths from carcinoma.

significant difference in probability of survival for the various age groups. The probability of obtaining a Chi square as large as the one found is approximately 0.4 if there is really no difference in survival rates by age. This, however, is misleading, as two factors are at work, high virulence in younger age groups, (Simmons et al., 10), and low virulence with low life expectancy in older groups. Utilizing the U.S. Life Tables for White Females (1939–41), one can construct a table illustrating this point. Thus in Table IV it is seen that the percentage of deaths due to carcinoma diminishes with increasing age. These data are based on tables showing the death rate from all causes in various age groups, and do not exclude deaths due to carcinoma, which in 1943 constituted 11.4 per cent of all deaths for both sexes.

Table V shows the end-results following various types of operation with irradiation given preoperatively or postoperatively. Since the groups in themselves are quite small, no effort was made to subdivide them further on a clinical basis. No allowance is therefore made for the possible effects of selection of cases upon the results of different therapeutic procedures. Thus, simple resection followed by postoperative irradiation showed a survival rate of 53 per cent, while none of 8 patients with simple resection receiving preoperative irradiation in addition to postoperative irradiation survived five years. Actually all of the latter cases had ulcerated lesions and the operative procedure was merely palliative.

TABLE V: FIVE-YEAR SURVIVALS IN VARIOUS TREATMENT GROUPS

Treatment and Period of Study	Total Cases	Five-Year Survivals
Radical Resection plus Postoperative Irradiation		
1902–31	179	47 (26%)
1932–39	94	48 (51%)
1902–39	273	95 (35%)
Simple Resection plus Postoperative Irradiation		
1902–31	46	16 (35%)
1932–39	34	18 (53%)
1902–39	80	34 (43%)
Radical Resection plus Pre- and Postoperative Irradiation		
1932–39	13	7 (54%)
Simple Resection plus Pre- and Postoperative Irradiation		
1932–39	8	0
Radical or Simple Resection plus Pre- and Postoperative Irradiation (Previous Two Groups)		
1902–31	27	8 (30%)
1932–39	21	7 (33%)
1902–39	48	15 (31%)
Radical Resection plus Preoperative Irradiation		
1932–39	9	2 (22%)
Local Excision plus Postoperative Irradiation		
1932–39	9	1 (11%)
Various Operations (unknown, local excision followed by simple mastectomy, etc.) plus Irradiation		
1932–39	20	7 (35%)
Irradiation alone		
1902–31	48	4 (8%)
1932–39	42	4 (10%)
1902–39	90	8 (9%)

The effect of irradiation upon survival is evaluated in Table VI. No significant effect is noted when the contralateral side is irradiated as well as the operated side. Since 1932, surgery alone has been the treatment in 162 cases, and the survival shows no statistically significant difference from that following routine postoperative x-ray therapy.

Again, when the cases subjected to radical mastectomy are grouped according to histologic evidence of lymph node involvement, no significant difference in

TABLE VI: INFLUENCE OF IRRADIATION UPON FIVE-YEAR SURVIVAL

Period of Study	Total Cases	Five-Year Survivals
Irradiation of Involved Side Only		
1902–31	204	45 (22%)
1932–39	56	23 (41%)
1902–39	260	68 (26%)
Prophylactic Irradiation		
1902–31	183	56 (30%)
1932–39	132	60 (45%)
1902–39	314	116 (37%)
All Irradiated Cases		
1932–39	188	82 (44%)
No Irradiation		
1932–39	162	65 (40%)

survival appears following irradiation (Table VII). It has been the practice in some parts of the country in recent years to give irradiation only if the lymph nodes show evidence of metastatic disease. Our results fail to show any improvement which could be due to irradiation given on such a basis.

TABLE VII: RADIATION EFFECT UPON SURVIVAL AS INFLUENCED BY AXILLARY METASTASES

	Irradiation Given		No Irradiation	
	Total Cases	Five-Year Survivals	Total Cases	Five-Year Survival
Axillary nodes histologically involved	75	26 (35%)	55	14 (25%)
Axillary nodes histologically uninvolved	35	25 (71%)	24	13 (55%)
Axillary nodes not reported by pathologist	18	8 (44%)	33	18 (55%)

Irradiation further fails to produce any significant effect upon the number of cases in which metastases or recurrences subsequently develop, as shown in Table VIII. Nor is there any apparent preventive effect upon the subsequent development of osseous (Table IX) or pulmonary metastases (Table X), or upon recurrent and metastatic disease of the chest wall and regional lymph nodes (Table XI).

Pleural effusion developed in 26 cases, 14 of them being in patients who had been irradiated postoperatively. The patients survived an average of eight months after the onset of the effusion, some as long as twenty-one months. One patient receiving moderate postoperative irradiation had an effusion and showed evidence of ununited rib fractures three years after treatment.

TABLE VIII: INFLUENCE OF IRRADIATION UPON METASTASES OR RECURRENCES

Period of Study	Total Cases	Number Developing Metastases or Recurrences
Irradiation of involved side only		
1902–31	204	88 (43%)
1932–39	56	39 (55%)
1902–39	260	127 (49%)
Prophylactic irradiation		
1902–31	183	88 (48%)
1932–39	132	72 (70%)
1902–39	314	160 (51%)
All irradiated cases		
1932–39	188	111 (59%)
No irradiation		
1932–39	162	107 (66%)

Both of these findings were believed to be due to irradiation. The patient survived seven years after the appearance of the fluid. At the time the chest was irradiated it was believed that the fluid was due to metastatic cancer.

The terms recurrent and metastatic disease of the chest wall are used rather loosely, and connote different things to

TABLE IX: OCCURRENCE OF BONE METASTASES

	Total Cases	Cases with Bone Metastases	Average Survival in Months following Appearance of Metastases
Irradiated cases			
Cases surviving less than five years	106	27 (25%)	12
Five-year survival group	82	11 (13%)	28
Total	188	38 (20%)	16
No irradiation			
Cases surviving less than five years	97	25 (26%)	8
Five-year survival group	65	10 (15%)	13
Total	162	35 (22%)	10

TABLE X: OCCURRENCE OF PULMONARY METASTASES

	Total Cases	Cases with Pulmonary Metastases	Average Survival in Months following the Appearance of Metastases*
Irradiated cases	188	47 (25%)	9
No irradiation given	162	32 (20%)	10

*Survival ranged from 1 to 35 months.

different workers. Actually, any cancer cell which has spread beyond the original focus of the disease is metastatic, and nodules recurring in the scar following mastectomy should be labeled metastatic disease. Popular usage implies that such nodules are recurrent from inadequate re-

TABLE XI: EFFECT OF IRRADIATION UPON RECURRENT DISEASE AND METASTATIC DISEASE TO CHEST WALL AND REGIONAL LYMPH NODES

	Irradiation Given		No Irradiation Given	
	Total Cases	Cases Showing Involvement	Total Cases	Cases Showing Involvement
Metastatic disease to chest wall and the lymph nodes following radical mastectomy	128	26 (20%)	112	32 (29%)
Recurrent disease in scar after simple and radical mastectomy	188	17 (9%)	162	19 (12%)

moval of the primary lesion, when actually they may result from dissemination from the original tumor which was not removed at operation. The proper approach to such lesions, when not too extensive, is wide surgical excision, with removal of enough of the chest wall. Several of the patients in our series owe their lives to the surgeon's intrepidity. When, however, the disease is extensive, operation through such an area may cause it to flare up immediately after surgery and spread very rapidly. Such extensive disease may be treated palliatively by low or intermediate voltage (40 kv. or 135 kv.) and held in check in some cases, although the general outlook is poor.

We had earlier expressed the belief that some patients appeared to do just as well following a simple mastectomy as after a more radical procedure. In the present series, a simple mastectomy was performed in 38 cases as a primary procedure where there was no question of palliation, and 50 per cent survived five years. If one could ascertain with certainty the presence or absence of lymph node involvement, then a simple procedure would suffice in many cases. Table XII, however, illustrates the danger of such a basis for deter-

TABLE XII: COMPARISON OF CLINICAL AXILLARY EXAMINATIONS WITH PATHOLOGICAL EXAMINATIONS

Status	Number of Cases
Positive clinically and pathologically	69
Negative clinically and pathologically	32
Negative clinically, positive pathologically	36
Positive clinically, negative pathologically	18

mining the appropriate surgical treatment. In 35 per cent of 155 cases in which there was evidence of adequate histologic examination of the axillary contents the clinical appraisal was in error. Failure to detect metastatic disease was more common than the error of considering an innocent axilla involved. Taylor and Bruce (12) found an error of 28 per cent in the clinical appraisal of lymph node involvement.

An interesting finding was the relatively high incidence of herpes zoster, 16 cases (4 per cent) occurring in 406 patients. There is no available statistical information concerning the incidence of this disease in the general population, and it is therefore impossible to give statistical proof that herpes is abnormally frequent in certain groups of diseases. It occurs in proportion of 1 to 2 per cent of all diseases of the skin on the basis of large surveys (2). In 200,000 admissions to Bellevue Hospital (New York), 131 cases of primary herpes zoster were encountered, an incidence of 0.06 per cent (3). A distinct clinical impression exists that it is more frequent in Hodgkin's disease, lymphosar-

coma and the leukemias (1), and there have been occasional case records of its association with tumor (5).

Fourteen of our patients with herpes received preoperative and postoperative irradiation, or both, only 2 receiving no irradiation. Fifteen cases occurred on the thorax and one on the face. Nine were on the same side as the breast lesion, 3 were on the contralateral side, and 4 could not be localized by the data available. The disease appeared anywhere from five months to three years after treatment of the breast lesion. In 12 of the 16 cases, however, there was evidence of metastatic disease either before or after the appearance of the cutaneous disease. This would tend to support the commonly accepted idea that herpes in such cases was due to involvement of the spinal ganglia by metastatic cancer. The remaining 4 patients survived between six and twelve years after the herpetic attack with no evidence of metastasis.

Diabetes mellitus was present in 13 patients, only 2 of whom survived more than five years. Eight of these patients were treated by x-ray, and in one the reaction in the axilla did not heal well. The belief has been expressed on occasions that such patients tolerate irradiation poorly, but our small series does not indicate this to be so.

The role of the endocrine glands has become increasingly important in cancer studies. The significance of the interplay of these organs in malignant neoplasms is not known, and our studies furnish no clue. However, 9 cases of non-toxic goiter and 12 cases of toxic goiter were observed in our cancer patients, 13 of the total 21 surviving more than five years.

Tuberculosis was discovered in 10 cases. Five of the patients received postoperative irradiation, and one of the lesions was believed to have been activated following irradiation.

It is well known that the incidence of a second primary cancer in patients having a previous malignant growth is higher than the incidence of cancer in the general population. In a series of 3,907 cancer autopsies, Warren and Ehrenreich (13) found multiple cancers in 6 per cent. This greater frequency, calculated as an elevenfold increase over cancer expectancy in the general population, was believed by the authors to represent susceptibility or predisposition to cancer in some persons or groups of persons. Twenty of our patients (4.9 per cent) either had a malignant neoplasm previously or developed one subsequently, while an additional patient developed an acute myeloblastic anemia. The distribution of these other tumors was as follows:

1 carcinoma of the thyroid
1 carcinoma in opposite breast
2 retroperitoneal sarcomas
5 carcinomas of ovary
1 sarcoma of cervix
1 carcinoma of cervix
1 sarcoma of fundus
2 carcinomas of uterine fundus
3 carcinomas of gallbladder
1 carcinoma of bladder
2 epidermoid carcinomas of skin

The carcinoma in the opposite breast developed eleven years after previous mastectomy and appeared histologically to be a new lesion.

X-ray castration was employed in 38 patients after the appearance of metastatic disease, with survival averaging fourteen months after the procedure, one patient living as long as five years. The procedure was employed immediately after mastectomy in 9 patients and 7 of these are alive at the present time, eight to ten years after operation; 2 died within thirteen months. These results do not help to clarify the role that castration should play in the therapy of carcinoma of the breast. It has been our belief that it should not be used routinely following operation, but only after osseous metastases appear, since its beneficial effect is apparently temporary. We would therefore employ it only when the need has arisen.

Lymphedema of the arm developed in 34 of the irradiated patients (18 per cent) and in 25 of the non-irradiated patients (16 per cent). Thirty-nine of those with

edema survived less than five years, and in 50 per cent of these axillary or supraclavicular nodes appeared either shortly before or after the edema. The edema most often became manifest less than a year postoperatively. Unless it appeared shortly after the operation, the time interval was no criterion for the presence or absence of metastatic disease as the causative agent. Early appearance was most often not associated with metastatic disease. The untreated cases in which metastases were of late occurrence often showed late development of edema.

DISCUSSION

It might appear from observing the percentages alone that in some cases of carcinoma of the breast superior results are attributable to irradiation. For the chief differences in percentages, paying due attention to sample sizes, Chi-square tests were run. In all cases the probability was found to be in excess of 0.05, and in only one case did it approach this figure. The insignificance we obtained may be attributable to two factors: (1) either there is no improvement in the end-results of treatment of carcinoma of the breast which could be due to irradiation, or (2), if there is improvement, it is so slight that with samples of the size considered here significant improvement is not evident. This can be answered only by continued evaluation of results.

At the present time irradiation in the management of carcinoma of the breast has been relegated to a solely palliative role. In the treatment of pain due to osseous metastasis, an effort is made to deliver 600 to 800 r to the lesion. The patients relieved of pain appeared to do much better than those not obtaining relief. Where irradiation fails, the therapist must then consider other control measures where applicable, as hormones, snake venom injections, rhizotomy, and cordotomy. It has been further observed that patients with pulmonary metastases complaining of dyspnea are often relieved by four daily treatments of 100 r measured in air delivered to the mediastinum. Cough was often relieved by about six daily doses of 50 r delivered to the chest through an open field. Sometimes the response was quite rapid and dramatic, even though the pulmonary lesions showed no change. In some cases, however, the cough was merely due to a bronchosinusitis, an entity which is often overlooked because of the history of cancer. Pleural effusion was best managed by repeated thoracenteses and irradiation of the involved hemithorax in an effort to control the pleural metastases. When possible, all cases subjected to surgery should have a preoperative bone survey in addition to a routine chest film. Patients with metastatic disease can thus avoid a radical procedure, which would be unnecessary in such a case. The roentgenograms also furnish a valuable basis for comparison in evaluating subsequent complaints. When vertebral disease may lead to cord compression, a supportive brace is an advisable prophylactic measure.

Irradiation alone may serve to control some lesions fairly adequately. Twelve patients who received neither irradiation nor surgery lived an average of fourteen months after first being seen, and an average of thirty-eight months after first noticing the disease. Forty-four patients treated only by irradiation lived an average of nineteen months after first being seen, and thirty-two months after first noticing the disease. Four of this latter group survived at least five years after first being seen, namely, ten, eight, six, and five years. The findings of Lenz (6) are encouraging in the management of some cases by irradiation alone when adequate dosage is employed. His results should encourage the use of larger doses than have been customarily employed. If large doses are used, however, one should watch the patient carefully. Loss of weight while receiving radiation is a danger sign, and treatment should be interrupted.

SUMMARY

1. A survey of 350 cases of carcinoma of the breast fails to reveal any significant

improvement in the five-year survival rate which could be attributed to postoperative x-ray therapy.

2. The role of irradiation in the palliative management of such cases is discussed.

3. There appears to be a relatively high incidence of herpes zoster which is probably due to metastatic spinal ganglion involvement.

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SUMARIO

El Papel de la Irradiación en la Asistencia del Carcinoma Mamario

El estudio de 350 casos de carcinoma de la mama no revela la menor mejora en el coeficiente de sobrevivencias de cinco años que pueda imputarse a la roentgenoterapia postoperatoria, razón esta por la cual se ha relegado a un papel puramente paliativo la irradiación en el tratamiento de dicho estado. Adminístrase para aliviar el dolor debido a las metástasis óseas y la disnea y tos derivadas de la invasión pulmonar. La irradiación por sí sola también ha ido seguida de cohibición bastante adecuada de algunas lesiones. Cuarenta y cuatro enfermos tratados exclusivamente con la irradiación vivieron por término medio diecinueve meses después de observárseles por primera vez, y treinta y dos meses desde que advirtieron por primera vez la enfermedad. Cuatro de este último grupo sobrevivieron, desde que se les vió la primera vez, por lo menos cinco años, o sea: diez, ocho, seis y cinco años.

En las enfermas con cáncer mamario se he observado una incidencia relativamente alta de zona (4 por ciento de 406 enfermas en las clientela de los AA.) Esto parece debido a invasión metastática de los ganglios raquídeos.

Spindle-Cell Tumors of the Gastro-Intestinal Tract[1]

WILLIAM L. PALAZZO, M.D.,[2] and MILFORD D. SCHULZ, M.D.

TUMORS IN THE gastro-intestinal tract are rarely non-epithelial in origin. The present discussion is limited to the small percentage which are found arising primarily from mesodermal tissue, the so-called spindle-cell tumors. The typical subdivisions of this group—the neurinoma or neurofibroma, the leiomyoma, and the fibroma—are histologically well defined. Many cases, however, falling into intermediate groups, are difficult to classify, and this difficulty becomes exaggerated when malignant counterparts of benign tumors ("sarcomas") are encountered. For this reason, the general terms "benign" and "malignant" spindle-cell tumor have been used. This investigation attempts to determine (*a*) the incidence of spindle-cell tumors in the gastro-intestinal tract; (*b*) the prospect for the patient in whom such a tumor is found; (*c*) what, if any, roentgenologic criteria there may be to aid in diagnosis, particularly in distinguishing between benign and malignant lesions.

TABLE II: RELATIVE INCIDENCE OF BENIGN AND MALIGNANT SPINDLE-CELL TUMORS IN THE GASTRO-INTESTINAL TRACT

	Benign	Malignant	Total
Esophagus	9	3	12
Stomach	75	18	93
Small intestine	11	12	23
Large intestine	6	6	12
TOTAL	101	39	140

TABLE I: INCIDENCE OF SPINDLE-CELL TUMORS OF THE GASTRO-INTESTINAL TRACT BY DECADES

Decade	Number of Malignant Tumors	Number of Benign Tumors	Total Tumors	Total Per Cent Corrected for Normal Population Decay
Second	0	2	2 (1.3%)	0.1
Third	2	1	3 (2.0%)	0.2
Fourth	4	9	13 (9.0%)	0.9
Fifth	9	17	26 (19.0%)	2.0
Sixth	4	22	26 (19.0%)	2.4
Seventh	16	26	42 (30.0%)	5.4
Eighth	4	17	21 (15.0%)	7.0
Ninth	0	6	6 (4.0%)	12.0
Tenth	0	1	1 (0.7%)	70.0
TOTAL	39	101	140 (100%)	100.0

MATERIAL

The study is based on 140 cases of spindle-cell tumor of the gastro-intestinal tract seen at the Massachusetts General Hospital. The material was culled from 12,000 autopsy protocols covering the years since 1900 and from 5,313 records of gastro-intestinal tumors histopathologically proved at operation since January 1931. Eighty-two cases were found in the postmortem protocols and 58 in the surgical records.

Of the 140 patients, 82 were male and 58 female. The ages ranged from sixteen to ninety-two years, with a median age of sixty. The incidence by decades is shown in Table I. If the incidence of spindle-cell tumors in the gastro-intestinal tract is corrected for the normal decay of population (2), it will be seen that there is a consistent rise in their appearance with age. There is no relative increase in the malignant varieties with increasing years.

[1] From the Department of Radiology, Massachusetts General Hospital, Boston, Mass. Presented at the Thirty-third Annual Meeting of the Radiological Society of North America, Boston, Mass., Nov. 30–Dec. 5, 1947.
[2] Trainee of the National Cancer Institute.

TABLE III: SPINDLE-CELL TUMORS OF THE GASTRO-INTESTINAL TRACT FROM NECROPSY PROTOCOLS AND SURGICAL RECORDS

	Esophagus		Stomach		Small Bowel		Large Bowel		Total		
	Incidental	Symptomatic	Incidental	Symptomatic	Incidental	Symptomatic	Incidental	Symptomatic	Incidental	Symptomatic	Grand Total
NECROPSY											
Benign	3	1	48	2	9	0	3	2	63	5	68
Malignant	0	2	2	2	2	4	0	2	4	10	14
Total	3	3	50	4	11	4	3	4	67*	15	82
SURGICAL											
Benign	1	4	7	18	0	2	0	1	8	25	33
Malignant	0	1	0	14	0	6	0	4	0	25	25
Total	1	5	7	32	0	8	0	5	8	50	58
GRAND TOTAL	4	8	57	36	11	12	3	9	75	65	140

* Nine of these had undergone surgical operation.

As shown in Table II, 12, or 9 per cent of the entire group of tumors, were located in the esophagus; 93, or 65 per cent, in the stomach; 23, or 17 per cent, in the small intestine; 12, or 9 per cent, in the large bowel. Benign tumors were almost three times as frequent as malignant tumors. Approximately this same ratio holds for the tumors of the esophagus and of the stomach. In both the small and large intestine, however, the occurrence of malignant tumors equalled or exceeded that of benign tumors.

INCIDENCE

In 12,000 consecutive postmortem examinations, there were found 82 spindle-cell tumors of the gastro-intestinal tract, a percentage occurrence of 0.67. It may be assumed that this approximates the percentage incidence in any given population group. It is, however, somewhat low when compared to the findings of others. Rienjets (3) reported 16 per cent spindle-cell tumors (leiomyomas) in routine postmortem examinations of the stomach in a group in which he also found a 6 per cent incidence of gastric carcinoma. In a study of 813 gastro-intestinal tumors in the Army Institute of Pathology, Ehrlich and Hunter (1) found 2 per cent to be of spindle-cell type. Table III shows that but 18 per cent of the spindle-cell tumors found in our autopsy series had caused any symptoms and that even in the "surgical" group 14 per cent were incidental findings.

TABLE IV: RELATIVE INCIDENCE OF SPINDLE-CELL TUMORS OF THE GASTRO-INTESTINAL TRACT TO ALL OTHER TYPES FOUND AT SURGICAL OPERATION DURING THE YEARS 1931–47

	Number of Tumors of All Types	Number of Spindle-Cell Tumors
Esophagus	390	9 (2.3%)
Stomach	818	42 (5.0%)
Small intestine	123	9 (7.0%)
Large intestine	3,982	7 (0.2%)
TOTAL	5,313	67* (1.2%)

* Fifty-eight (58) from Surgical Group (Table III) plus 9 from Postmortem Group.

Table IV shows the relative frequency of occurrence of spindle-cell tumors in various parts of the gastro-intestinal tract compared to tumors of all types. (For this purpose material from the surgical records alone was used.) Spindle-cell tumors accounted for 1.2 per cent of all the gastro-intestinal tumors operated upon in the past sixteen and a half years. The highest percentile occurrence, 7 per cent, was in the small bowel; the lowest, 0.2 per cent, in the large bowel. In the esophagus and stomach the figures are 2.3 and 5 per cent, respectively.

EXPECTANCY

In determining the prospect of a patient in whom a tumor of the spindle-cell variety was found, the 67 who were subjected to surgical procedures are considered. Since benign tumors of the gastro-intestinal tract in this series did not contribute

TABLE V: EXPECTANCY IN SPINDLE-CELL TUMORS OF ESOPHAGUS

Tumor	Operative Death	Dead with Disease	Alive with Disease	Dead without Disease	Alive without Disease	Total
BENIGN	1	0	1	1	3	6
MALIGNANT	2					
Duration (postoperative)						
0–1 yr.		0	1	0	0	
Total	2	0	1	0	0	3
GRAND TOTAL	3	0	2	1	3	9

TABLE VI: SPINDLE-CELL TUMORS OF THE STOMACH: EXPECTANCY

Tumor	Operative Death	Dead with Disease	Alive with Disease	Dead without Disease	Alive without Disease	Total
BENIGN	2	0	0	7	18	27
MALIGNANT	2					
0–1 year		1	0	0	0	
2–3 years		1	2	0	0	
3–4 years		0	1	0	2	
6–10 years		0	0	0	4	
Over 10 years		0	0	1	1	
Total malignant	2	2	3	1	7	15
GRAND TOTAL	4	2	3	8	25	42

directly to the death of the patient, the survival period of only those with malignant tumors is tabulated.

Esophagus (Table V): Of 9 patients with esophageal spindle-cell tumors subjected to surgery (2 in the upper, 5 in the mid, and 2 in the lower esophagus), one-third died shortly thereafter. Four benign tumors were successfully removed, and the patients have remained free of disease. In one patient, multiple, extensive leiomyomas were not resected but, so far as is known, the growth has not inconvenienced him greatly during the two years since the diagnosis was established.

The malignant tumors are too few in number to warrant the drawing of any conclusions; only one patient is alive, but with disease.

Stomach (Table VI): Of the 42 patients operated on for spindle-cell tumors of the stomach, 4 succumbed shortly following the surgical procedure, 2 with benign and 2 with malignant tumors. The remaining 25 benign tumors were removed successfully, and the patients remained free of disease thereafter.

Of the 15 patients in whom the tumors were malignant, 5 have either died of their disease or are alive but with recurrent disease between one and four years after surgery. Eight, or more than half, remained well and free of disease four years or longer (2 for more than ten years), an average duration of eight years. Of the 5 patients in whom the disease was not controlled, 2 had local recurrence, 4 had metastases to the liver, and 1 had involvement of abdominal lymph nodes.

In contrast to the well known poor prognosis for patients in whom malignant growths of epithelial origin are found (5), the expectancy for one with a gastric spindle-cell tumor of any variety is favorable. Three-fourths of those in the present series are well and apparently free of disease for significant periods of time. Even of those patients in whom the tumor was malignant, more than half have survived, well and free of disease, four years or more after surgical removal. In all the patients who died or are alive with disease, the tumor recurred within four years.

Small Intestine (Table VII): Of the 9 patients with spindle-cell tumor of the small intestine, 2 died immediately following surgery; in both, the tumors were malignant. Two patients with benign

TABLE VII: EXPECTANCY IN SPINDLE-CELL TUMORS OF SMALL INTESTINE

Tumor	Operative Death	Dead with Disease	Alive with Disease	Dead without Disease	Alive without Disease	Total
BENIGN	0	0	0	0	2	2
MALIGNANT	2					
Duration (postoperative)						
0–1 yr.		3	0	0	0	
1–2 yr.		1	0	0	0	
2–3 yr.		1	0	0	0	
Total	2	5	0	0	0	7
GRAND TOTAL	2	5	0	0	2	9

TABLE VIII: EXPECTANCY IN SPINDLE-CELL TUMORS OF LARGE INTESTINE

Tumor	Operative Death	Dead with Disease	Alive with Disease	Dead without Disease	Alive without Disease	Total
BENIGN	0	0	0	0	1	1
MALIGNANT	2					
Duration (postoperative)						
0–1 yr.		2	0	0	0	
2–3 yr.		1	0	0	0	
4–5 yr.		0	0	0	1	
Total	2	3	0	0	1	6
GRAND TOTAL	2	3	0	0	2	7

tumors are alive and free of disease. All 5 patients with malignant tumors who survived operation died within three years.

In this group, malignant tumors occurred three times as frequently as benign tumors and proved highly fatal.

Large Intestine (Table VIII): Spindle-cell tumors of the colon are uncommon both relatively and absolutely. Of the 7 in this series, 1 was benign (the patient is alive and without disease) and 6 were malignant. Two patients in the latter group died postoperatively; only one, who had a fibrosarcoma of the rectum, is alive and well five years after operation.

CRITERIA FOR ROENTGEN DIAGNOSIS

Esophagus: Characteristically, spindle-cell tumors in the esophagus are intramural and extramucosal. The typical appearance has been described by Schatzki and Hawes (4). They demonstrated that it was not possible to differentiate with any degree of certainty between true intramural tumors and extrinsic masses which are closely applied and fixed to the wall of the esophagus. The mucosal surface of these tumors is usually intact; the defects they produce involve but one wall of the esophagus. They have sharply defined upper and lower margins and, when seen face on, may expand the esophagus (Fig. 1). All spindle-cell tumors, however, do not show these characteristic findings. Some have more the appearance of unusually large, extensive, ulcerating neoplasms, often indistinguishable from carcinoma, and in our experience such tumors have been malignant. In the present series, all 3 of the malignant tumors showed ulceration; in 2 it was very extensive and both simulated carcinoma (Fig. 2). None of the benign tumors was ulcerated.

Three of the esophageal tumors were pedunculated and lay within the lumen (1 malignant, 2 benign); 5 were intramural (1 malignant, 4 benign); and 1, a sarcoma, was sessile and cauliflower-like in character. All of the malignant tumors, and all but one of the benign, were lobulated. The size of the tumors, varying from 5 to 10 cm., in greatest diameter, had no relation to malignancy. Of the 3 largest tumors, measuring approximately 10 cm. in greatest diameter, 2 were benign and 1 malignant.

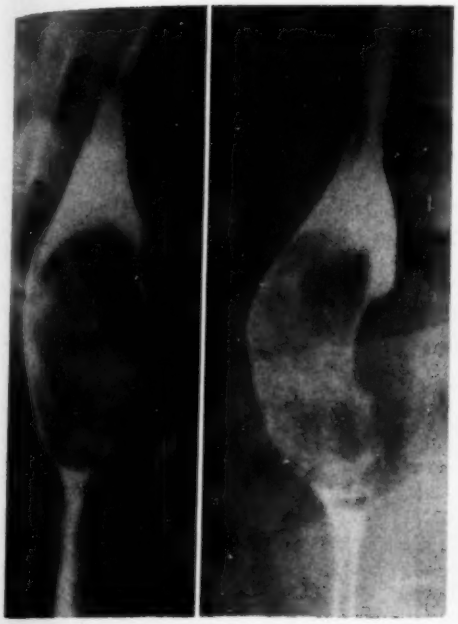


Fig. 1. Benign spindle-cell tumor of esophagus. Note attachment of the tumor to one wall and the widening of the esophagus.

Fig. 2. Malignant spindle-cell tumor of esophagus which has undergone extensive ulceration, simulating carcinoma.

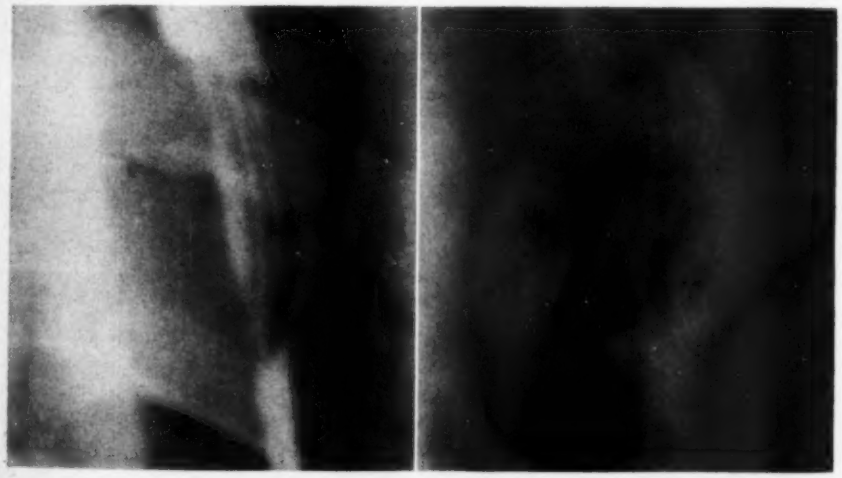


Fig. 3. Bronchiogenic cyst of esophageal wall producing a defect similar to that of an intramural spindle-cell tumor.

Spindle-cell tumors of the esophagus are roentgenologically recognized as such when they lie in the wall of the esophagus, but they may not be differentiated from other masses arising in or closely applied and fixed to the wall. Cysts of the esophageal wall (Fig. 3), mediastinal cysts, tuberculous lymph nodes (Fig. 4), and even de-

Fig. 4. Tuberculous node attached to wall of esophagus producing a defect simulating that of an intramural spindle-cell tumor.

fects produced by vascular anomalies, have been mistaken for intramural esophageal tumors.

Although there are no safe criteria for determining with certainty the benignity of an esophageal spindle-cell tumor, in our experience, smoothly circumscribed intramural tumors which lie in the wall of the esophagus, over which the mucosa is intact, and which may or may not be lobulated, have proved to be either benign spindle-cell tumors or some non-neoplastic process attached to the esophagus. A malignant spindle-cell tumor with very extensive ulceration probably cannot be differentiated from carcinoma.

Stomach: The characteristic appearance of a spindle-cell tumor of the stomach is that of a smooth, sharply outlined mass

TABLE IX: SPINDLE-CELL TUMORS OF STOMACH SURGICALLY TREATED

Gross Tumor	Malignant (15)	Benign (27)
Ulcerated	8 (54%)	9 (33%)
Size		
Under 5 cm.	2 (13%)	15 (56%)
Over 5 cm.	13 (87%)	12 (44%)
Lobulated	9 (60%)	10 (37%)
Pedunculated		
Intraluminal	1 (7 %)	3 (11%)
Extraluminal	3 (20%)	3 (11%)
Distribution		
Cardia and fundus	4 (27%)	9 (33%)
Body	7 (46%)	13 (48%)
Antrum	4 (27%)	5 (19%)

protruding into the lumen. The mucosa over the mass is intact, except in about half of the instances, when it may be broken by a circumscribed area of ulceration (Fig. 5). Dimpling of the mucosa has often been mentioned as a characteristic feature of a spindle-cell tumor, but in the present series only 2 of the removed specimens showed such dimpling.

Frequently the appearance of a spindle-cell tumor arising in the wall of the stomach is not classical. Of the 35 gastric tumors under discussion, 6 appeared roentgenologically to be large abdominal masses pressing upon, although probably fixed to, the wall of the stomach (Fig. 6). One was thought to be a pancreatic cyst. Four, showing extensive ulceration of gastric mucosa, could not be differentiated from carcinoma or lymphoma (Fig. 7). In 20 instances only was the diagnosis of spindle-cell tumor made.

Fifty-four per cent of the malignant tumors showed ulceration as compared to 33 per cent of the benign. Eighty-seven per cent of the malignant tumors, in contrast to 44 per cent of the benign, were over 5 cm. in diameter. This might indicate either more rapid growth of malignant tumors or the possibility that benign tumors may undergo malignant change. The number of benign and malignant tumors which were lobulated was about equal, but the percentile occurrence of lobulation in the malignant group was almost twice that in the benign; this may be due to the greater average size of malignant tumors (Table IX).

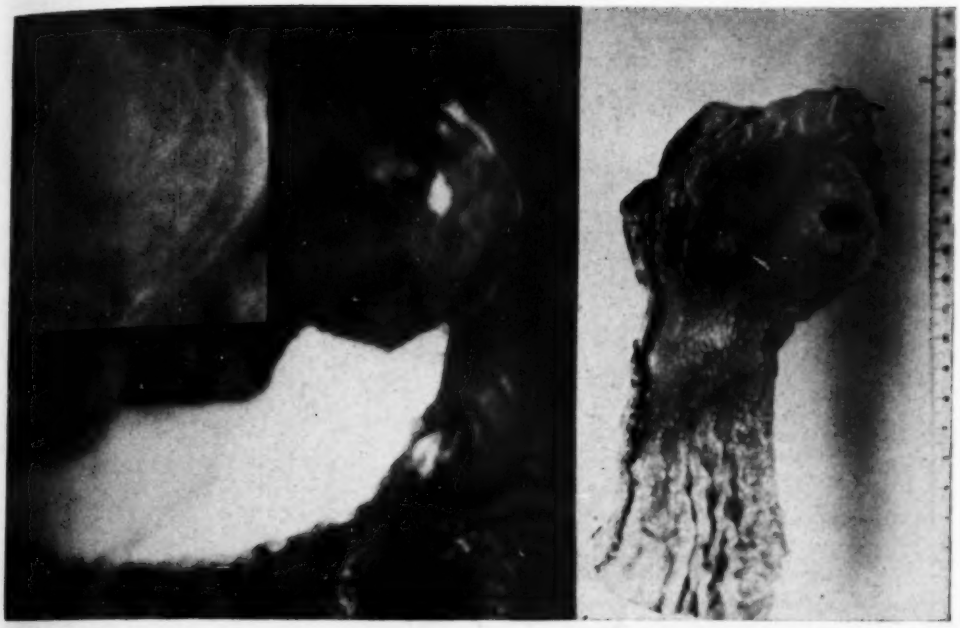
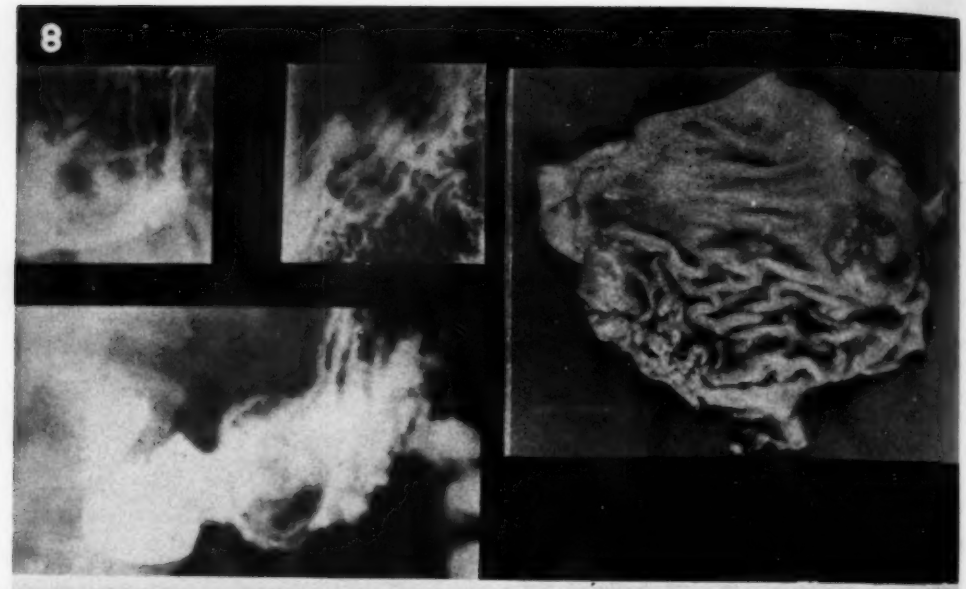


Fig. 5. Benign spindle-cell tumor of stomach wall producing a typical smoothly outlined defect. Note the deep undermined ulcer.

Fig. 6. Large malignant spindle-cell tumor arising from greater curvature of stomach and projecting out into the peritoneal cavity.

Fig. 7. Extensive ulcerated malignant spindle-cell tumor of stomach simulating carcinoma.



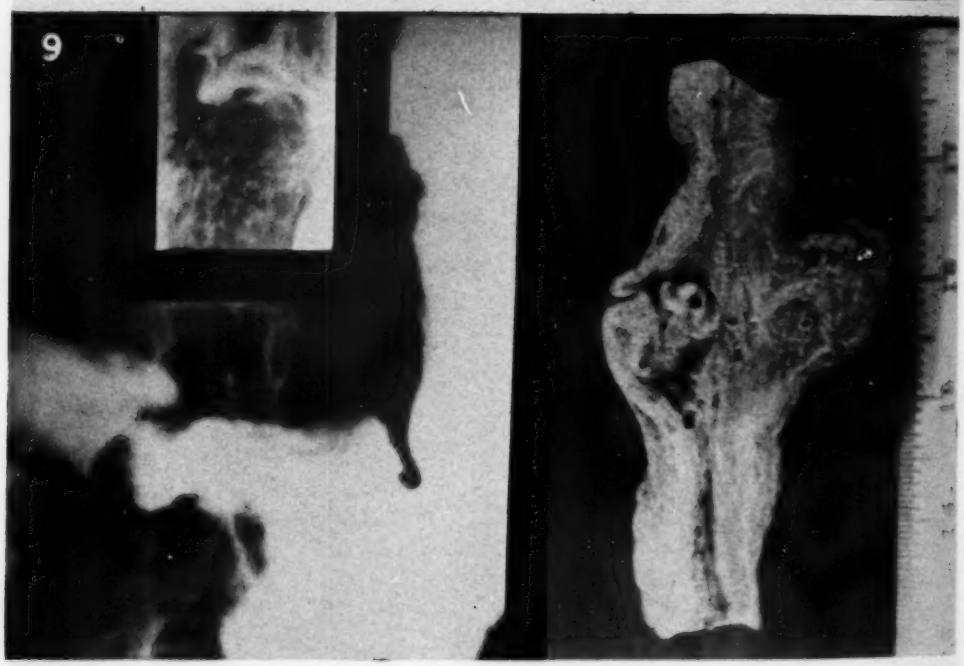


Fig. 8. Small non-ulcerative malignant spindle-cell tumor of stomach. Fatal recurrence following resection.
Fig. 9. Ectopic pancreatic tissue in stomach wall producing a defect indistinguishable from an intramural spindle-cell tumor.

If a spindle-cell tumor shows extensive ulceration of the gastric mucosa and has the appearance of carcinoma, it is probably malignant, but its histology cannot be predicted. Even if the roentgenologic appearance of a spindle-cell tumor is more

Fig. 10. Pancreatic cyst producing a defect somewhat like that of a spindle-cell tumor.

or less classical, the determination of its benignancy or malignancy is not possible with any degree of certainty. While it is true that malignant spindle-cell tumors of the stomach characteristically tend to be larger than the benign, and more frequently lobulated and ulcerated, exactly similar conditions may be associated with benign lesions, and some small, smooth, non-ulcerative tumors have proved to be fatally malignant (Fig. 8). Both benign and malignant tumors have been observed to increase in size over a period of years.

In the stomach, as in the esophagus, the defects characteristic of spindle-cell tumors can be simulated by any non-neoplastic mass either in or fixed to the stomach wall. Ectopic pancreas (Fig. 9), adherent spleen, tumors in the pancreas (Fig. 10) or liver, may all produce defects in the roentgen shadow which may be mistaken for spindle-cell tumor.

Small Intestine: The roentgenologic diagnosis of any tumor of the small intestine has been unsatisfactory; it was not made in any of the 9 spindle-cell tumors in this series. In only 3 instances was the presence of any tumor reported; in 2 it was called a malignant tumor at the head of the pancreas (Fig. 11) and in the third, the roentgen diagnosis was "a malignant tumor." Partial obstruction of the small bowel was described in one case, and intestinal obstruction in another; in 4 cases no abnormality was noted.

Large Intestine: In none of the 7 spindle-cell tumors of the colon here reported was the nature of the lesion recognized roentgenologically. Carcinoma was diagnosed in 3 cases (Fig. 12); in another a perirectal swelling was described, and in one the colon was reported as normal, although subsequent surgery disclosed a leiomyosarcoma of the sigmoid, 2 × 4 × 5 cm. In 2 instances, no examination was made.

The material in both the small and large bowel series is inadequate to permit the drawing of any conclusions.

SUMMARY AND CONCLUSIONS

Spindle-cell tumors of the gastro-intestinal tract were found in 0.67 per cent of 12,000 necropsy protocols and in 1.2 per cent of 5,313 surgical records at the Massachusetts General Hospital. Both benign and malignant varieties occurred with increasing frequency as age progressed.

Of the total 140 spindle-cell tumors, 9 per cent were located in the esophagus, 65 per cent in the stomach, 17 per cent in the small intestine, and 9 per cent in the large intestine.

Spindle-cell tumors accounted for 2.3 per cent of all tumors surgically removed from the esophagus in the past sixteen years, for 5 per cent of those in the stomach, for 7 per cent of those in the small intestine, and for 0.2 per cent of those in the large intestine.

Of the spindle-cell tumors found in the esophagus, 33 per cent were malignant. In the stomach, 36 per cent were malignant, and 54 per cent of the patients bearing the tumors remained well and free of disease for an average of eight years. Recurrence or metastasis, if present, was evident within four years. Metastases to the liver and lymph nodes occurred in 33

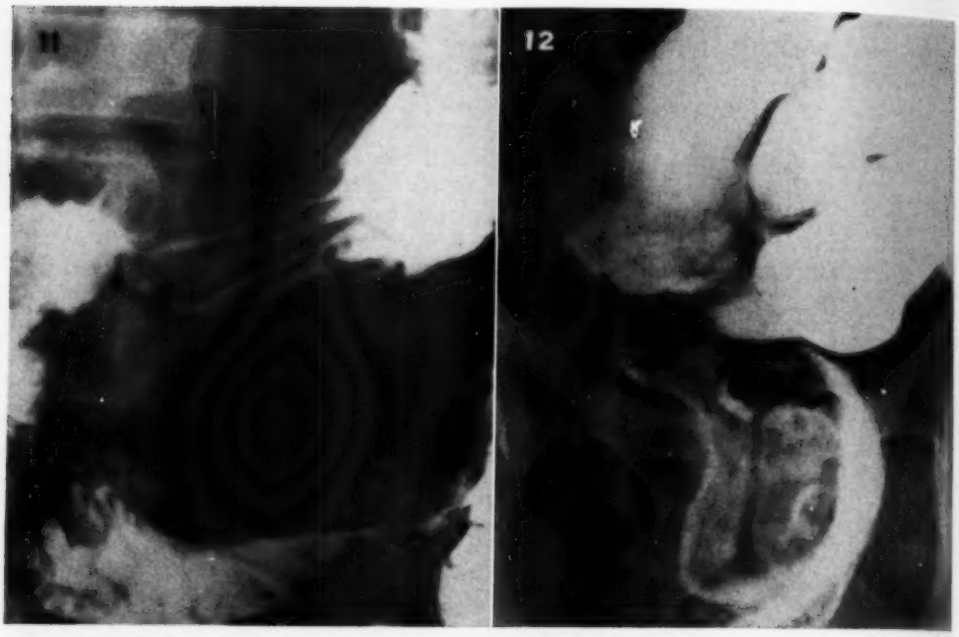


Fig. 11. Malignant spindle-cell tumor arising from third portion of duodenum simulating a tumor in the pancreas.
Fig. 12. Malignant spindle-cell tumor of rectum grossly simulating carcinoma.

per cent of the malignant gastric tumors. In the small bowel 77 per cent of the spindle-cell tumors were malignant; none of the patients remained free of disease for longer than three years. Eighty-six per cent of the spindle-cell tumors in the large bowel were malignant. Only one patient of this group is alive; she is without disease five years after operation.

This study has not demonstrated any safe criteria by which the benignity of a spindle-cell tumor may be recognized with certainty. Similar morphologic and growth characteristics are shared by both benign and malignant tumors. Some spindle-cell tumors, obviously malignant, may not be roentgenologically recognized as spindle-cell in type but may be mistaken for carcinomas.

In our experience, recognition of spindle-cell tumors as such has not proved to be as satisfactory in the small and large intestine as in the esophagus and stomach.

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SUMARIO

Tumores Fusocelulares del Tracto Gastrointestinal

En 0.67 por ciento de 12,000 protocolos de autopsias y en 1.2 por ciento de 5,313 historias quirúrgicas del Hospital General de Massachusetts encontráronse tumores fusocelulares del tubo gastrointestinal. A medida que avanzaba la edad, aumentaba la frecuencia de las variedades benignas a la par que malignas.

Del total de 140 tumores fusocelulares, 9 por ciento radicaban en el esófago, 65 por ciento en el estómago, 17 por ciento en el intestino delgado y 9 por ciento en el intestino grueso.

Los fusocitomas representaban 2.3 por ciento de todos los tumores extirpados quirúrgicamente del esófago durante los últimos 16 años, 5 por ciento de los del estómago, 7 por ciento de los del intestino delgado y 0.2 por ciento de los del intestino grueso.

De los descubiertos en el esófago, 33 por ciento eran malignos. De los del estómago, 36 por ciento eran malignos y 54 por ciento de los enfermos afectados permanecieron bien y sin signos de enfermedad durante un promedio de ocho años. Las recurrencias o metástasis, cuando las hubo, se manifestaron en término de cuatro años. En 33 por ciento de los gastromas malignos hubo metástasis en el hígado y ganglios linfáticos. En el intestino delgado 77 por ciento de los tumores fusocelulares fueron malignos, y ningún enfermo continuó sin signos de enfermedad más de tres años. Ochenta y seis por ciento de los fusocitomas del intestino grueso fueron malignos, y un solo enfermo (una mujer) de este grupo se halla viva, habiendo estado sin signos de enfermedad por cinco años.

Este estudio no ha revelado la menor pauta fehaciente para reconocer con seguridad la benignidad de un tumor fusocelular. Los tumores benignos y malignos comparten por igual semejantes características de morfología y desarrollo. Algunos de ellos, manifiestamente malignos, tal vez no sean reconocidos radiográficamente como fusocitomas, sino confundidos con carcinomas.

En la experiencia de los AA., el reconocimiento de los tumores fusocelulares, como tales, no ha resultado tan satisfactorio en el intestino delgado y grueso como en el esófago y estómago.

An Analysis of X-Ray Findings in 405 Cases of Benign Gastric and Pyloric Ulcer[1]

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THE PURPOSE OF this study was primarily: (*a*) to determine the most frequent sites of benign gastric ulcers and (*b*) to discover the reasons for the differences in location as reported by the radiologist, surgeon, and pathologist. In the course of our investigation, however, we took advantage of a comprehensive follow-up of a large number of cases to evaluate the results obtained by medical and surgical treatment. We believe that this information is of enough interest and importance to warrant its inclusion in a radiological presentation.

The material upon which the paper is based consists of 429 gastric and pyloric ulcers in 405 patients hospitalized during the past fifteen years. There are included in this number several chronic ulcers found incidentally at autopsy.

TERMINOLOGY

A review of the literature reveals considerable confusion in anatomical terminology in reference to the stomach, particularly the distal portion, as shown in Figure 1. This confusion is shared by the anatomist, surgeon, pathologist, and roentgenologist. We feel that there is a definite need for standardization of nomenclature, and offer our suggestions in Figure 2. The term "antrum" we apply to that portion of the stomach between the incisura angularis and the pylorus. We have divided the antrum into two parts, calling the distal 2.5 cm. the prepyloric area.

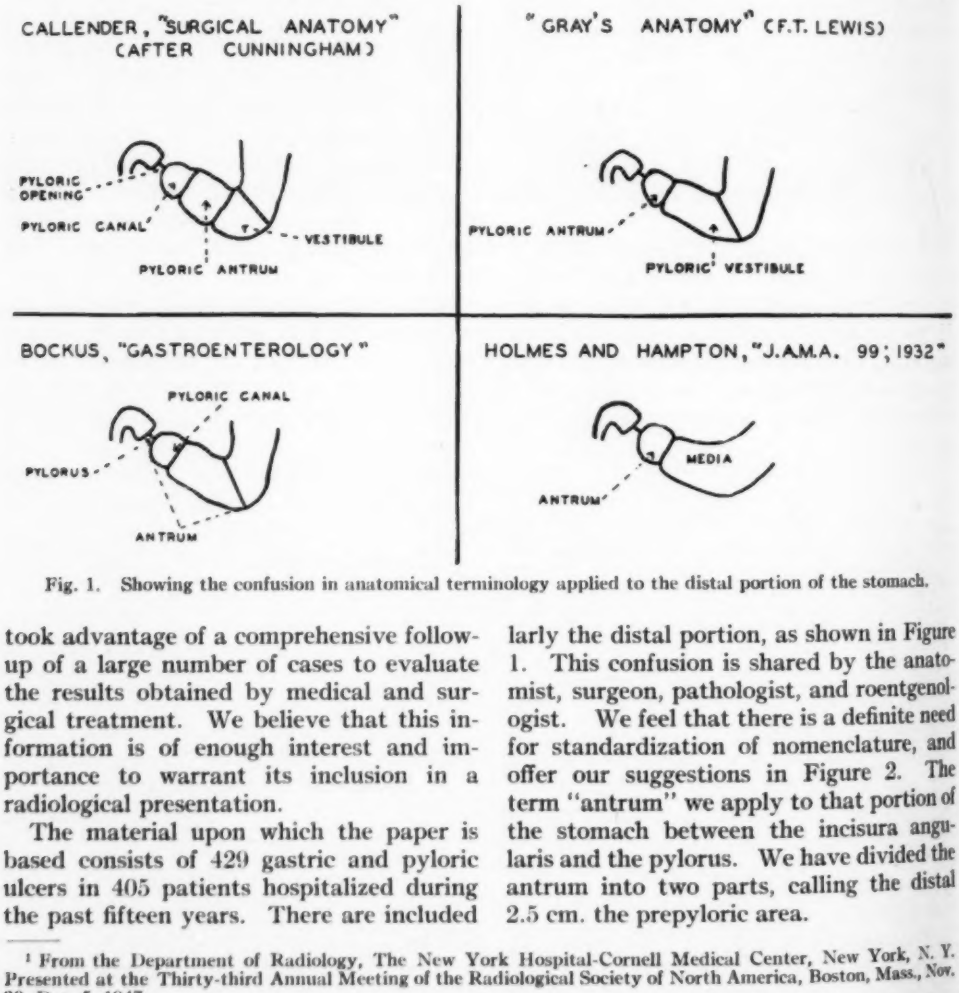

Fig. 1. Showing the confusion in anatomical terminology applied to the distal portion of the stomach.

[1] From the Department of Radiology, The New York Hospital-Cornell Medical Center, New York, N. Y. Presented at the Thirty-third Annual Meeting of the Radiological Society of North America, Boston, Mass., Nov. 30–Dec. 5, 1947.

In our experience, the greatest confusion has arisen from the loose way in which the word "pylorus" is used. Actually, this term should be applied only to the aperture between the stomach and duodenum. Many, however, have referred to any portion of the stomach distal to the incisura angularis as the pylorus. For example, in locating an ulcer in the prepyloric area in

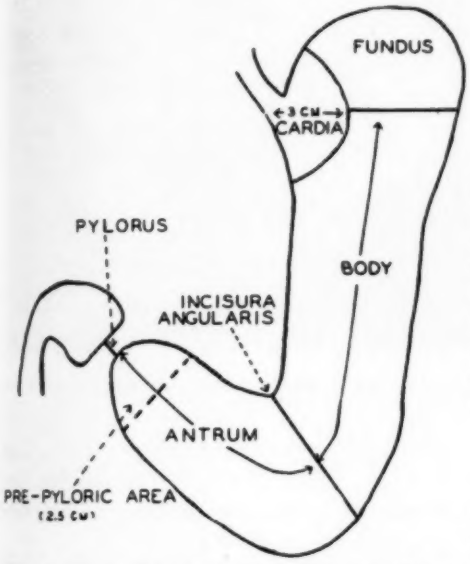

Fig. 2. Proposed anatomical terminology applied to the entire stomach.

one case, the surgeon reported as follows: "Inspection revealed an indurated area approximately 1.5 cm. in diameter on the anterosuperior surface of the *pylorus* just proximal to the ring." In another case, the pathologist, in describing an ulcer at the pyloric ring, made the following statement: "The specimen consists of the pyloric portion of the stomach and part of the duodenum. Of the *pylorus* there is about 5 cm.; of the duodenum 3.5 cm. At the junction of the two, on the lesser curvature, there is a small deep ulcer 7 mm. in diameter." Similar mistakes are frequently made by the radiologist.

The term "parapyloric ulcer" is confusing and should not be used, since it may mean any one of three things: (*a*) an ulcer

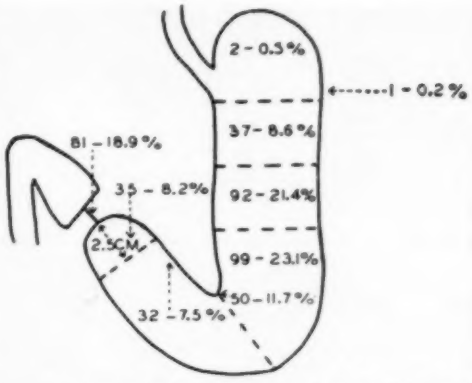

Fig. 3. Anatomical distribution of 429 gastric and pyloric ulcers in 405 patients.

originating in the base of the duodenal bulb and extending to the pyloric and prepyloric regions; (*b*) an ulcer primary in the pylorus and extending to the stomach and duodenum; (*c*) ulceration in the prepyloric area which may involve both the pylorus and the base of the cap. For a similar reason the term "juxtapyloric ulcer" is often ambiguous.

LOCATION OF ULCERS

In this series, 278 ulcers (64.8 per cent) were located in the pars media and incisura angularis, mostly along the posterior wall of the lesser curvature (Fig. 3). Similar findings have been reported by Hampton (3), Walters and Clagett (8), and others.

Reports as to the incidence of pyloric ulcers are contradictory. Butsch (2), for example, in 1935, reported that only 46 pyloric ulcers could be found in the surgical records at the Mayo Clinic during the preceding fifteen years, and that of these 46 cases, only 4 were accurately localized by x-ray. Eustermann, in the discussion of Butsch's paper, made the following statement: "Ulcers actually originating in, and confined to, the pyloric ring are much more infrequent in our experience than the incidence of 3 to 4 per cent reported in the literature would indicate. Undoubtedly some ulcers in the present series of 46 cases involved the pylorus by extension, either from the gastric or pyloric

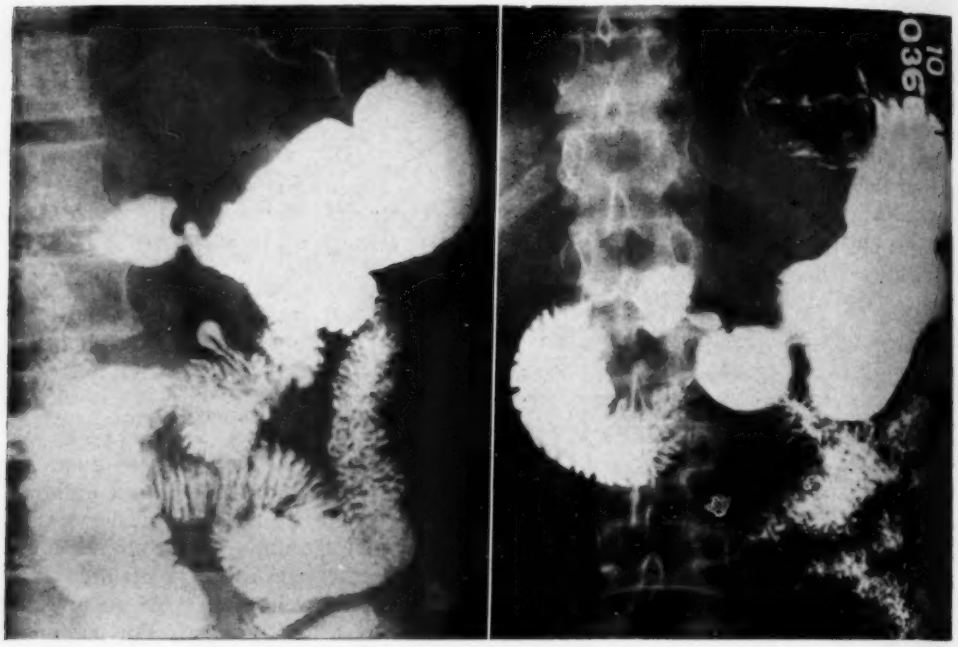

Fig. 4. Two cases of pyloric ulcer showing the lengthening of the pyloric sphincter (wide interval), the distortion of the pyloric sphincter (crooked stem), and the niche.

side." In 1942, Kirklin and MacCarty (4), reporting a series of 190 prepyloric, pyloric, and duodenal lesions, mentioned no benign pyloric ulcers. Hampton, on the other hand, in a series of 128 benign gastric ulcers, found 21.9 per cent to be pyloric. In our series we found 81 pyloric ulcers (18.9 per cent). We believe that such a discrepancy in the reported incidence would not exist if the following criteria were accepted for the diagnosis of a pyloric ulcer: (*a*) a lengthening of the pyloric sphincter (wide interval); (*b*) distortion of the pyloric sphincter (crooked stem); (*c*) a niche, usually small, located within the elongated canal (Fig. 4).

While it is well known that the prepyloric area is the most common site for malignant ulcerations, there are conflicting reports as to the incidence of benign lesions in this region. Hampton found only 2 (1.6 per cent) in his series of 128 cases. In our series there were 35 prepyloric ulcers (8.2 per cent), which agrees with the findings of Singleton (7), who reported 15 (10 per cent) out of a group of 145. In 22 of our 35 cases, proof of a benign lesion was obtained at operation, and 6 have been followed five years or longer.

Aside from 2 ulcers in the fundus, and one on the greater curvature, the remaining ulcers in our series, 32 (7.5 per cent) were in that portion of the antrum proximal to the prepyloric area.

COMPARISON OF LOCATION AS DETERMINED RADIOLOGICALLY AND SURGICALLY

Most radiologists have probably been disturbed, just as we have been, by the discrepancy between the radiological location of a lesion and that reported by the surgeon, and occasionally by the pathologist. Most of the discrepancies have occurred in the region of the pylorus. We have attempted to discover the reasons for these discrepancies. There are several difficulties which may confront the surgeon when he attempts to localize a lesion near the pylorus. As the result of anesthesia, the pyloric muscle is relaxed and the

stomach and duodenum form a continuous tube. The pyloric muscle itself frequently cannot be palpated. If he attempts to use the pyloric vein as a guide, he is faced with the fact that this may vary in its course. In addition, the structures may be distorted by adhesions. The radiologist, on the other hand, can be more accurate, since during his examination there is a distinct dividing line between the stomach and duodenum, produced by the pyloric sphincter. He is able, therefore, as a rule, to say definitely whether the lesion is prepyloric, pyloric, or postpyloric. This is important, inasmuch as a large proportion of the prepyloric lesions are malignant, and the radiologic report should influence the surgeon as to the type of operation to be performed. The pathologist, also, may be unable to localize a lesion because the specimen may be inadequate in size, may not contain sufficient anatomical landmarks, or may be macerated by surgical clamps.

In Table I, the x-ray localization is compared with the surgical findings in 198 cases in which operation was performed within a few days following the roentgen examination. The findings were in agreement in 135 instances (68 per cent). There was disagreement in 22 cases (11 per cent) and in 9 of these the roentgen localization was verified by the pathologist, whereas the surgical location was verified in only one. In 30 cases no exact localization was given by the surgeon, beyond the statement, in most instances, that the lesion was on the lesser curvature. The pathologist verified the x-ray localization in 6 of these cases. The pathological report gave no information as to location in 123 instances in which specimens were submitted.

TABLE I: COMPARISON OF RADIOGRAPHIC AND SURGICAL LOCATION IN 198 CASES

NUMBER OF ULCERS - 198			
	NUMBER	PERCENT	
AGREEMENT	135	68%*	
DISAGREEMENT	22	11%	X-RAY VERIFIED BY PATHOLOGY - 9 SURGERY VERIFIED BY PATHOLOGY - 1 NO PATHOLOGICAL VERIFICATION - 12
NOT LOCALIZED BY SURGERY	30	16%	X-RAY VERIFIED BY PATHOLOGY - 6 NO PATHOLOGICAL VERIFICATION - 24

* X-RAY AND SURGERY AGREE BUT PATHOLOGY DISAGREES - 6

NOT LOCALIZED BY PATHOLOGY - 123

NO SPECIMEN SUBMITTED - 20

RESULTS OF MEDICAL AND SURGICAL TREATMENT

The medical and surgical cases have been divided into determinate and indeterminate groups. The determinate group in each instance includes all cases with a follow-up of one year or more, as well as cases terminating fatally in less than one year. The indeterminate group includes all other cases without a one-year follow-up. Total percentages are based upon the determinate group, whereas mortality figures are based upon both the determinate and indeterminate groups. We have designated the result as "fair" when ulcer symptoms were recurrent but x-ray findings were negative and "poor" when recurrent symptoms were associated with a positive roentgen picture. It should be emphasized that all cases in our series were hospitalized, and presumably were more serious than those maintained on a medical regimen in the Outpatient Department.

TABLE II: RESULTS OF MEDICAL TREATMENT

YEARS	NUMBER OF CASES	DETERMINATE GROUP				INDETERMINATE GROUP
		GOOD	FAIR	POOR	SUBSEQUENT OPERATIONS	UNKNOWN
UNDER 1 YEAR	56		1	4		51
1 – 5	106	43	4	59	26	
6 – 12	31	15	5	11	4	
TOTAL	193	58 40.8%	10 7%	74 52.1%	30 21.1%	

DIED OF HEMORRHAGE – 7

TABLE III: RESULTS OF GASTRIC RESECTION

YEARS	NUMBER OF CASES	DETERMINATE GROUP			INDETERMINATE GROUP
		GOOD	FAIR	POOR	UNKNOWN
UNDER 1 YEAR	39			7	32
1 – 5	112	108	2	2	
6 – 14	32	31		1	
TOTAL	183	139 92.1%	2 1.3%	10 6.6%	

OPERATIVE MORTALITY 7 – 3.8%

The results in 193 cases treated medically are shown in Table II. Good results were observed in 40.8 per cent, fair in 7 per cent, and poor in 52.1 per cent. These figures are based upon a determinate group of 142 cases. Included under poor results are 7 cases in which death was due to hemorrhage. Operation was subsequently performed in 21.1 per cent of the determinate group, included here under poor results.

The results of 183 gastric resections are shown in Table III. Based upon a determinate group of 151, 92.1 per cent had good results, 1.3 per cent had fair results, and 6.6 per cent poor results. Included under poor results are 7 postoperative deaths, giving an operative mortality for gastric resection of 3.8 per cent. Incidentally, we did not find a single instance in which marginal ulcer developed following this type of operation.

The results of 60 surgical procedures excluding gastric resections are shown in Table IV. In a determinate group of 56, good results were obtained in 62.5 per cent, fair in 5.4 per cent, and poor in 32.1 per cent. The operative mortality was 6.7 per cent (4 cases).

Comparative results of medical and sur-

TABLE IV: RESULTS OF SURGICAL PROCEDURES EXCLUDING GASTRIC RESECTION (GASTRO-ENTEROSTOMY, 36. EXCISION AND GASTRO-ENTEROSTOMY, 13. MISCELLANEOUS OPERATIONS, 11)

		DETERMINATE GROUP			INDETERMINATE GROUP
YEARS	NUMBER OF CASES	GOOD	FAIR	POOR	UNKNOWN
UNDER 1 YEAR	10			6	4
1 – 5	23	15	2	6	
6–14	27	20	1	6	
TOTAL	60	35 62.5%	3 5.4%	18 32.1%	

OPERATIVE MORTALITY 4 – 6.7%

TABLE V: COMPARISON OF RESULTS OF MEDICAL AND SURGICAL TREATMENT

	DETERMINATE GROUP		
	MEDICAL	SURGICAL	
		RESECTION	OTHER OPERATIONS
NUMBER OF CASES	145	151	56
GOOD	40.8%	92.1%	62.5%
FAIR	7%	1.3%	5.4%
POOR	52.1%	6.6%	32.1%

gical treatment are shown in Table V. Not included under either medical or surgical results are 14 cases of acute perforation requiring plication. In 10 of these, results were poor. There were 8 deaths in this group and 6 patients required subsequent resection.

SIZE OF ULCERS

MacCarty (5) has stated that at least 90 per cent of all chronic gastric ulcers more than 2.5 cm. in diameter are definitely cancers. We determined the size of 310 ulcers, and found that whereas 275 (88.7 per cent) measured less than 2.5 cm., 35 (11.3 per cent) were of that size or larger (Table VI). Of these 35 ulcers, 26 were proved benign following resection, and 5 cases had a medical follow-up of five years or more.

TABLE VI: SIZE OF ULCERS

UNDER 2.5 CM	275	88.7%
2.5 CM AND OVER	35*	11.3%

*31 PROVEN BENIGN BY SURGERY OR MEDICAL FOLLOW-UP OF 5 YEARS OR MORE

We found the correlation between x-ray, surgical, and pathological measurements, wherever given, to be very close.

AGE AND SEX INCIDENCE

Age and sex incidence for this series is shown in Table VII. There were 297

TABLE VII: AGE INCIDENCE AT TIME OF ADMISSION, AND SEX INCIDENCE

AGE GROUP	MALE		FEMALE		TOTAL	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
10 – 19	0	0%	1	0.9%	1	0.2%
20 – 29	5	2%	1	0.9%	6	1.5%
30 – 39	37	13%	12	11%	49	12.1%
40 – 49	105	35%	36	33%	141	34.8%
50 – 59	90	30%	29	27%	119	29.4%
60 – 69	51	17%	24	22%	75	18.5%
70 – 79	9	3%	5	5%	14	3.5%
TOTAL	297		108			
	73.3%		26.7%			

YOUNGEST PATIENT – 12 YEARS
OLDEST PATIENT – 75 YEARS

40 YEARS AND OLDER – 85.9%

TABLE VIII: DIAGNOSTIC ACCURACY IN 371 RADIOGRAPHIC EXAMINATIONS

TOTAL NUMBER OF X-RAY EXAMINATIONS 371		
	NUMBER	PERCENT
CALLED MALIGNANT	22	5.9%
CALLED PYLORIC OBSTRUCTION	6	1.6%
ULCER NOT SEEN	5	1.3%
TOTAL	33	8.8%

(73.3 per cent) males and 108 (26.7 per cent) females. This preponderance of males, 2.7:1, agrees with the commonly accepted textbook figures.

The peak for age incidence for all patients was the fifth decade, with 34.8 per cent, followed by the sixth decade with 29.4 per cent; 85.9 per cent of all patients were forty years of age and older. The youngest patient was twelve, and the oldest seventy-five. There was no significant sex difference in age incidence in our series, a finding similar to that of Bockus (1). Portis and Jaffé (6) however, on the basis of autopsy studies, gave the age peak for males as fifty-one to sixty years and for females as thirty-one to forty.

ACCURACY OF DIAGNOSIS BY X-RAY

The accuracy in x-ray diagnosis in 371 instances is shown in Table VIII. In 22 cases (5.9 per cent) the lesions were called malignant. Pyloric obstruction was noted in 6 cases (1.6 per cent) without the lesions being identified or located. In 5 instances (1.3 per cent) the ulcers were not seen. This constitutes a definite diagnostic error of 8.8 per cent. In the remaining 91.2 per cent the diagnosis was equivocal in an undetermined number of cases in which the

observer called the lesion benign but stated that malignancy could not be ruled out.

MULTIPLE ULCERS

Multiple gastric ulcers were observed in 23 cases (5.7 per cent). Triple ulcers were seen once, and the rest were double ulcers. In the case of the triple ulcers, and in 10 instances of double ulcers, the lesions were observed simultaneously.

Duodenal ulcers, either active or healed, were associated with gastric ulcers in 41 cases (10 per cent).

SUMMARY

1. The confusion in anatomical terminology in reference to the stomach is emphasized, and a plea is made for the adoption of precise nomenclature to be used and understood equally well by the roentgenologist, surgeon, and pathologist.

2. Of 429 ulcers in 405 cases, 64.8 per cent occurred on the lesser curvature of the body of the stomach, including the region of the incisura angularis. A relatively high number, 8.2 per cent, were located in the prepyloric area; 18.9 per cent occurred at the pylorus. The radiographic criteria for diagnosis of pyloric ulcer are given.

3. The reasons for the discrepancies between the radiographic and surgical location of a lesion, particularly in the region of the pylorus, are discussed. It is our opinion that the x-ray diagnosis of location is by far the more accurate.

4. A comparison is made between the results of medical and surgical treatment in patients requiring hospitalization. The treatment of choice is gastric resection, which showed 92.1 per cent good results as compared with 40.8 per cent for medical management.

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SUMARIO

Análisis de los Hallazgos Roentgenológicos en 405 Casos de Ulcera Gástrica y Pilórica Benigna

Al recalcar la confusión que reina en la terminología anatómica relativa al estómago, abógase por la adopción de una nomenclatura precisa que usen y comprendan por igual el radiólogo, el cirujano y el patólogo. El término "píloro" debe limitarse a la abertura entre el estómago y el duodeno.

De 429 úlceras benignas en 405 enfermos, 64.8 por ciento se hallaban en la curvatura menor del cuerpo del estómago, comprendiendo la región de la incisura angular. Una proporción relativamente elevada, 8.2 por ciento, correspondían a la zona prepilórica, y 18.9 por ciento al píloro mismo.

Ofrécense las siguientes pautas para el reconocimiento radiológico de la úlcera pilórica: (a) elongación del esfínter pilórico (espacio ancho); (b) distorsión del esfínter (vástago torcido); (c) nicho, por lo general pequeño, en el elongado conducto.

En 22 de los 198 casos de la serie descrita, en los que se operó a los pocos días del examen roentgenológico, discreparon los hallazgos radiológicos y quirúrgicos en cuanto a la localización de la úlcera. Considérase que el diagnóstico roentgenológico es mucho más exacto.

El tratamiento de elección es la resección gástrica, que dió 92.1 por ciento de resultados buenos, comparado con 40.8 por ciento con la asistencia médica.

Roentgenologic Deformities of the Pyloric Portion of the Stomach with Absence of Surgical and Pathological Findings[1]

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THE ENIGMA OF pyloric filling defects without demonstrable pathology has intrigued us for years, and we have sought to discover some common denominator explaining the discrepancy between our radiologic observations and the findings of the surgeon and pathologist. In our study of pyloric defects we have found it feasible to refer to three groups: (*a*) those produced by mechanical pressure, whether of intraluminal, intramural, or extraluminal origin; (*b*) those due to physiological causes; (*c*) those which may be described as purely functional.

Intraluminal conditions, such as polyps, hair balls, foreign bodies, etc., often cause pyloric defects. Intramural lesions, also, such as leiomyomata, may produce defects which at times resemble those due to malignant change. The extraluminal conditions that simulate malignant involvement of the pylorus are numerous. Many of them are related to inflammatory, benign, or malignant changes in the liver, pancreas, duodenum, gallbladder, or colon. Lymph-node enlargement from inflammation or metastatic involvement may also produce defects of the pylorus, due to the special arrangement of the lymphatics at that site. Physiological causes for pyloric filling defects include variations in the spinal contour, the presence of congenital mesenteric bands, variations in size and relationship of surrounding organs, etc. There are also filling defects which may be attributed to deranged or pathological physiology involving remote organs of the body, such as disease processes of the appendix, heart, lungs, kidneys, generative organs, and central nervous system. Finally we have the purely functional cases, in which we can find no pathologic basis for the pyloric changes but which nevertheless appear to constitute a definite entity.

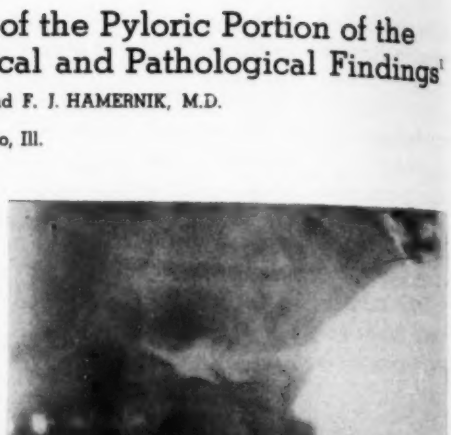

Fig. 1. Case I: Narrowing of pars pylorica.
Fig. 2. Case II: Narrow, rigid, irregular pars pylorica.

As may readily be appreciated from this classification, such a multiplicity of etiologic factors play a part in producing changes radiologically simulating pyloric disease that we have been unable to determine a common factor which can be said to be responsible for the pseudo-filling de-

[1] Presented at the Thirty-third Annual Meeting of the Radiological Society of North America, Boston, Mass., Nov. 30–Dec. 5, 1947.

fects which we are discussing. The following cases in which a diagnosis of malignant changes of the pylorus was made, but in which surgery or autopsy failed to reveal any pyloric lesion, are more or less typical.

CASE I (Fig. 1): J. P., white male aged 60, entered the hospital in December 1939, complaining of weight loss, weakness, loss of appetite, dizziness, and the passage of black stools for the past ten days. He appeared well nourished and well developed. Physical examination revealed slight enlargement of the liver. No definite tumor could be palpated in the abdomen. Blood studies showed red cells 3,390,000; white cells 11,400; hemoglobin 8.8 gm. Stools were positive for blood. Gastric analysis showed no free hydrochloric acid.

X-ray examination revealed an organic lesion involving the pars pylorica. The rugae were absent in this portion of the stomach, and no peristaltic waves passed through the pylorus.

On exploration, an indurated area was found just beyond the pyloric antrum in the first part of the duodenum. It gave the impression of being due to an old duodenal ulcer, with marked evidence of fibrosis. There were no nodules in the liver or any other signs of metastasis. There was nothing to indicate the presence of a malignant growth.

The roentgen examination in this case revealed a sharply demarcated lesion involving several centimeters of the pylorus. Certainly these changes are not representative of a nonmalignant lesion.

CASE II (Fig. 2): F. M., white male aged 78, entered the hospital in December 1938, complaining of weakness, shortness of breath, and some weight loss. He had been well until three or four weeks earlier, when he first began to feel weak and dizzy. He could not walk more than a block without becoming short of breath. He gave a history of a gallbladder operation in 1929, and of a peptic ulcer about eight years previously. He appeared well developed and well nourished and not acutely ill. His blood pressure was 160/94. Chest examination showed the lungs to be clear. The heart was slightly enlarged to the left.

The gastro-intestinal x-ray examination revealed a hyperactive stomach. The pylorus was narrowed, rigid, and irregular. Both curvatures also were definitely irregular. The duodenal bulb showed a concavity at its base. There was a large diverticulum in the second part of the duodenum.

An exploratory operation revealed dense fibrous adhesions over the pylorus, which the surgeon attributed to the previous gallbladder operation. Recovery was uneventful and symptoms were relieved.

CASE III (Fig. 3): T. G., white male aged 57, was first admitted to the hospital in February 1941, because of blood in the stools. In September 1941, he experienced a similar loss of blood and was examined at another hospital, where several transfusions were given and a fluoroscopic examination was done. The patient stated that a lesion was found in the stomach at that time, but its nature could not be determined because of language difficulty.

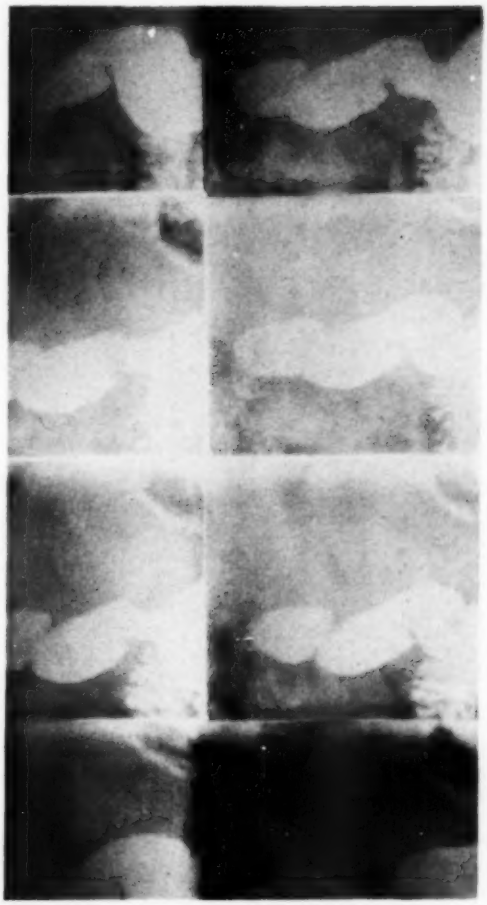

Fig. 3. Case III: Constant incisura on the greater curvature of the pars pylorica.

On physical examination, the patient appeared fairly well developed, but poorly nourished, with signs of recent weight loss. His blood pressure was 160/80. The abdomen was not tender, nor could any masses be palpated. The Wassermann reaction was negative. Urinalysis was negative. The red blood cell count was 4,500,000, with hemoglobin 14.0 gm. Gastric analysis showed free hydrochloric acid 7, combined hydrochloric acid 9, total 16.

The x-ray examination of the gastro-intestinal tract revealed a definite incisura on the greater curvature, which was constant. There was also narrowing at the junction of the pars media and pars pylorica. The angulation was sharp and the lumen at this point was definitely narrowed, the narrowing

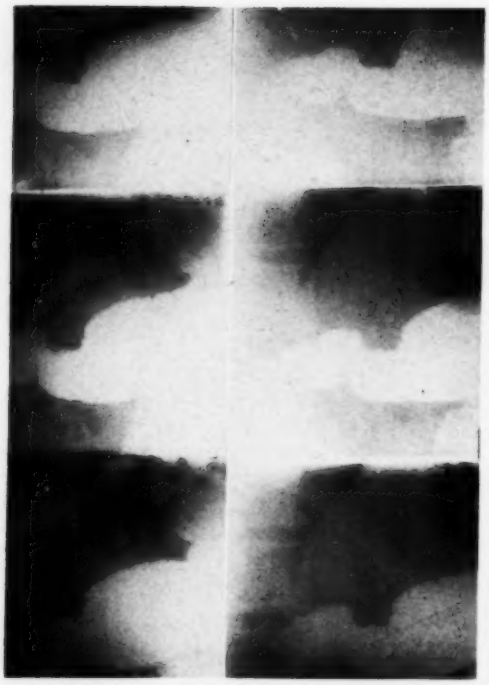

Fig. 4. Case IV: Constant filling defect in lesser curvature of the pars pylorica.

persisting after the administration of antispasmodics. No ulcer craters or filling defects could be outlined.

Inasmuch as the patient had bled freely on two occasions, exploration seemed indicated. This showed an adhesion between the greater omentum and the pylorus, which was probably responsible for the defect demonstrated by x-ray. The stomach was opened and showed no ulcer or malignant lesion. There was, however, a slight dimpling of the mucosa at the site of the adhesion.

CASE IV (Fig. 4): S. B., white male aged 52, complained of gas and heart pain. He had pain between the shoulders, accompanied by pounding of the heart. He entered the hospital for a complete check-up, which included a gastro-intestinal x-ray study. The physical examination showed the patient to be fairly well developed, well nourished, and not acutely ill. The lungs were clear and the heart was within normal limits. No abdominal masses could be palpated. The gastro-intestinal examination revealed a constant filling defect involving the lesser curvature of the pars pylorica. There was no sign of an indurating malignant lesion. The patient recently died from unknown cause, but the attending surgeon believed a carcinoma of the liver was responsible.

CASE V (Fig. 5): A. B., aged 63, entered the hospital in April 1940, complaining of pain in the epigastrium, loss of appetite, and distress after eating solid foods, especially meat. He had lost seven pounds in the last seven months. He had first experienced nausea and inability to eat solid foods about three years previously. He vomited occasionally. Symptoms had gradually progressed up to the time of admission. The only pertinent fact revealed by the past history was a cholecystectomy in

Fig. 5. Case V: Constant narrowing of pars pylorica, suggestive of annular carcinoma.

1933. The patient was fairly well developed and well nourished, and was well preserved for his age. A small mass about the size of a golf ball was palpable in the epigastrium. The blood count was normal. Roentgen examination showed definite narrowing of the pylorus suggesting an annular carcinoma.

At operation, a definite cord-like band of adhesions, about 1.0 cm. wide, was found surrounding the pyloric end of the stomach. This band, which was probably continuous with the lower border of the falciform ligament of the liver, was removed. Nothing suggestive of a malignant growth was noted after removal of the band.

CASE VI (Fig. 6): L. M., a white male aged 61, complained of weakness, dizziness, and vomiting. Fluoroscopy revealed a very spastic narrow pylorus, but re-examination after the administration of atropine showed a normal appearance. Subsequent medical studies led to a diagnosis of encephalomalacia of the internal capsule due to hemorrhage. This case clearly illustrates the value of re-examination after administration of an antispasmodic.

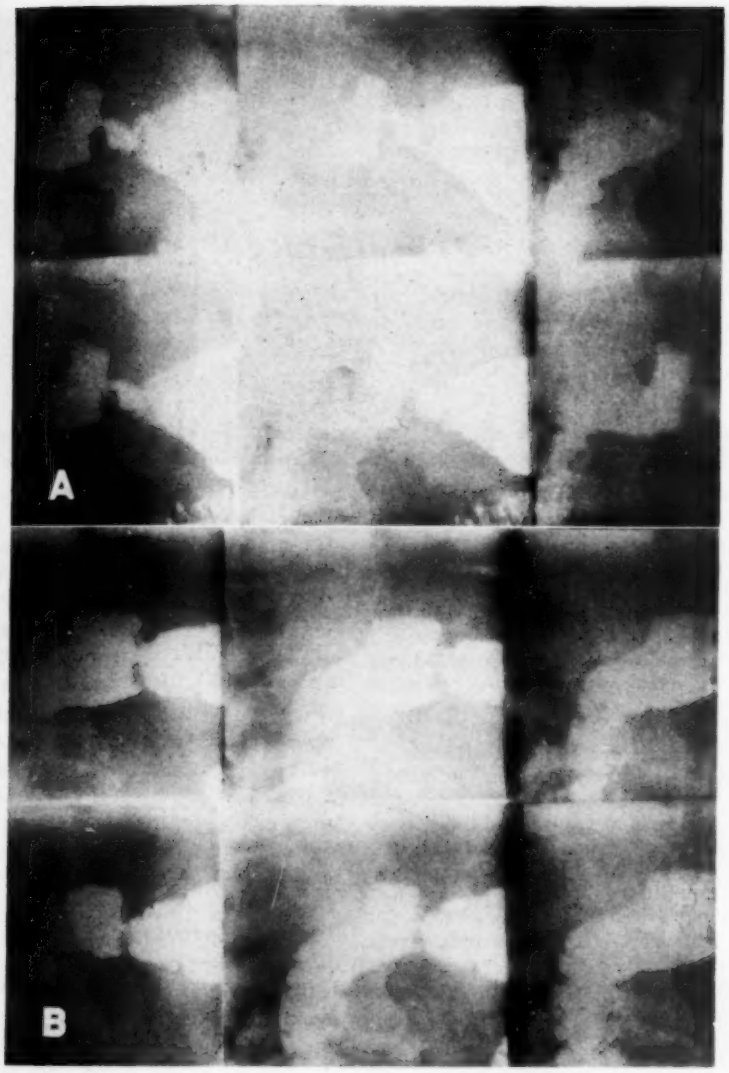

Fig. 6. Case VI: A. Narrowing of pars pylorica before atropine. B. Normal pars pylorica following atropine.

CASE VII (Fig. 7): R. C., a well nourished, well developed white male aged 51, had experienced abdominal distress for the past year. At first this manifested itself by belching and later by dyspepsia, for which he had taken soda. More recently he had suffered pain, and in the past few days had vomited everything ingested. He gave a history of diarrhea and forceful bowel movements for the past thirty years. The only significant finding on physical examination was slight tenderness over the right upper quadrant of the abdomen.

Gastroscopy was unsatisfactory. The pylorus was not seen, and only a few thick folds were noted in the cardia. X-ray examination revealed a narrow deformed pars pylorica which was thought to be characteristic of carcinoma of the stomach. One week prior to our examination the patient had been examined by Dr. Case, who expressed the opinion that there was an organic filling defect of the pylorus. Repeated examinations under atropine showed no alteration in the defect. An electrocardiogram showed sinus rhythm with no abnormalities. Other findings were as follows: blood Wassermann test negative; sedimentation rate 5; urine negative;

Fig. 7. Case VII: Filling defect of pars pylorica before (A) and after (B) operation; still present two years later (C).

stools negative on two occasions and on one showing a weak reaction to benzidine. An Ewald test meal showed free hydrochloric acid 56, combined hydrochloric acid 12, total 68. The red blood count was 5,090,000; white count 9,500; hemoglobin 15.1 gm. Blood chemistry findings were non-protein nitrogen 37 mg., sugar 104 mg., cholesterol 150 mg., icterus index 5 units. There was a slight indirect Van den Bergh reaction. Stools were negative for ameba.

An exploratory laparotomy was done. When the stomach was exposed, it appeared to be perfectly normal, but as soon as it was manipulated it went into extreme spasm. This later relaxed and the appearance was again normal. The stomach was incised above the pylorus on the anterior wall and nothing was noted internally. A biopsy of the full thickness of the wall was taken and pathological examination showed entirely normal gastric tissues without leukocytic infiltration.

The patient remains well, but the roentgen findings are unchanged.

In most of the cases reported above, and in others not recorded here, our primary impression was of a malignant lesion of the stomach, and we believe that, from a roentgenologic point of view alone, this was justified. Even clinically most of these cases, though thoroughly studied by competent clinicians and surgeons, simulated malignant disease. On closer analysis, however, we note that almost invariably the patient was "well nourished, well developed, not acutely ill," or that "symptoms had been present for many years," or were "predominantly those of cardiovascular disease," or that "the laboratory findings were at variance with the expected findings." Hardly one of these cases gives a classical picture of carcinoma commensurate with the roentgenologic picture.

To a great degree this is probably true of most diseases, including carcinoma of the stomach in some stages, but it is our impression that cancer involving the pyloric region to the extent here demonstrated usually follows a more classical pattern. The symptoms of anorexia, epigastric weakness, hematemesis or melena, and loss of weight can be said to be quite constant. If these symptoms are progressive over a period of six months to a year and are not appreciably altered by dietary or medical management, we could with reason expect a roentgen picture such as was obtained in most of these cases. At the same time, and by the same token, we would be dealing with an inoperable carcinoma.

To diagnose an early cancer is, of course, entirely possible, but it is done only by the closest attention to the details of change in dietary habits and symptoms or by routine x-ray check-ups. When the classical symptoms have supervened, it is more than likely that the condition is inoperable.

It is obvious that several of the cases

presented represent nothing more than the mechanical effect of extraluminal adhesions or bands and whatever spasm may have been produced secondarily by irritation of vascular and nervous origin. The presence of congenital bands is related to the development of the stomach and its rotation on the long axis of the foregut. In the seven-week embryo there is already a differentiation of the primitive foregut. The entire region of the stomach elongates, but the dorsal border grows more rapidly than the ventral wall, producing an outpouching that represents the greater curvature in contrast to the slower growing lesser curvature. The dorsal mesentery is growing rapidly during this period to form the omental bursa, while the ventral mesentery grows more slowly. All of these factors cause a rotation of the foregut in the stomach region and a change in the relationships of the borders. What had been the posterior wall of the primitive foregut comes to occupy the left side, while the ventral wall forms the lesser curvature, which is directed to the right.

The liver lies within the ventral mesentery. During the process of rotation of the stomach, the portion of the mesentery which lies between that organ and the liver is also rotated. This portion becomes the lesser omentum, designated regionally as the hepatogastric and hepatoduodenal ligaments. The portion which connects the liver with the ventral abdominal wall becomes the falciform ligament. Departures from this normal course of development may result in congenital bands such as are described in some of the cases recorded above.

In other cases, mechanical extraluminal changes are the result of adhesions in the gallbladder region, or of healing of old ulceration in the duodenum, involving inflammatory changes with infiltration of fibroblasts and formation of scar tissue.

Cases showing no intrinsic lesions, but which are associated with inflammations or malignant disease of contiguous organs, are most likely due to lymphatic spread of a pathological process. The pyloric region of the stomach is richly supplied with lymphatics. Those along the lesser curvature of the pylorus drain into the celiac nodes around the celiac artery; those of the greater curvature drain into the subpyloric nodes, which in turn empty into the celiac nodes. The lymphatic system of the upper portion of the lesser curvature drains into a group of nodes near the hiatus, which also drain the lower end of the esophagus. The upper portion of the greater curvature is poorly supplied with lymphatics and these drain into nodes around the splenic artery. There is free communication of lymphatics from the liver and contiguous structures to the celiac group of nodes. Any inflammatory or metastatic lesion in these groups, therefore, would cause blocking of the celiac nodes and retrograde dilatation of the lymphatics to the pyloric region of the stomach. Undoubtedly some of the findings in the cases reported above were due to edema of the layers of the stomach from this cause.

As a purely anatomical explanation for the lesions described, this appears to be logical. Why lesions of contiguous structures do not invariably produce this effect is more difficult to explain.

Nervous manifestations affecting the pyloric portion of the stomach, as distinguished from purely functional disease, must involve either of the vagi, or both, and the sympathetic division of the greater and lesser splanchnics. The immediate source of nerve fibers to the stomach is the celiac plexus, which receives fibers from the greater splanchnic, lesser splanchnic, and the vagus. This network is located about the celiac axis and the aorta in the immediate region of the celiac artery. Nerve fibers from the celiac plexus make up Auerbach's plexus, which is located in the muscular layers of the stomach and contains both sympathetic and vagus components. This nerve supply correlates the movements of the stomach. Meissner's plexus, which also contains vagus and sympathetic components, lies in the submucosa. It is associated with and receives

fibers from Auerbach's plexus and correlates the secretory functions of the glands with peristaltic activity. The vagi, of course, originate in series with the glossopharyngeal above and the spinal accessory below, from the lateral portions of the medulla, and send both afferent and efferent fibers to the stomach through the plexuses previously mentioned.

The sympathetic fibers arise from the thoracolumbar sympathetic ganglion and chiefly from the 6th, 7th, 8th, and 9th thoracic spinal nerve ganglia. The possibility of lesions involving the brain stem or the course of the nerve fibers in the vagi or sympathetic chain are so manifold that it is surprising that more lesions are not seen as a result of nerve involvement or reflex stimulation.

The arterial blood supply of the pyloric region is chiefly through the hepatic branch of the celiac axis, but through anastomotic channels it is also supplied by the left gastric and splenic branches of the axis. The venous drainage of the pyloric region is also slightly different than that in the other portions of the stomach. The right gastric vein, running along the lesser curve of the stomach between the layers of the lesser omentum, is formed by branches from the anterior and posterior surfaces of the pylorus. It drains into the portal vein. The greater curvature of the pylorus is drained by the right gastro-epiploic vein, which also enters the portal vein. The closer promixity of the pyloric vessels to the hepatic circulation may conceivably account for some vascular engorgement in diseases of the liver. This vascular engorgement could possibly be responsible for some of the changes in several of our cases.

Perhaps it would be reasonable to say that pyloric narrowing always represents disease, whether of intrinsic or extrinsic nature. The uncertainty of determining extrinsic disease in the presence of pyloric malformation demonstrable radiologically is subject to all of the possibilities enumerated. Our embarrassment in the face of negative findings by the surgeon is tempered by the satisfaction of knowing that exploratory examination alone is a relatively harmless procedure. Failure to operate, however, in the presence of a malignant condition would cause us much more embarrassment, if we had laid too great stress on the benign conditions which cause filling defects in the pylorus.

Even though we have examined and found what we thought was an organic filling defect in a pylorus that was proved to be normal, either by surgery or autopsy, we are of the opinion that these patients should be carefully watched, as it is hard to believe, after having examined thousands of stomachs, that these deformities could be present in a normal organ.

As Frank H. Lahey, in discussing prepyloric lesions says, "I am certain that there are prepyloric defects as demonstrated by roentgenogram that cannot be made to disappear by any known drug or plan of treatment. This being the situation, to find no lesion at exploratory operation when the roentgenologic defect is probably due to a prepyloric spasm is definitely better than at a later date to find that the lesion is malignant and that the favorable time for removal has passed. This is too high a price to pay for a simple exploration." The same can be said of any other prepyloric lesion under similar circumstances.

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SUMARIO

Deformidades Roentgenológicas de la Porción Pilórica del Estómago sin Hallazgos Quirúrgicos o Patológicos

Varios factores etiológicos pueden ser la causa de nichos pilóricos indicativos de lesión maligna, lo cual, sin embargo, confutan la operación o la autopsia. Esos nichos corresponden a tres grupos: (a) los producidos por la presión mecánica, de origen ya intraluminal, intramural o extraluminal; (b) los debidos a causas fisiológicas; (c) los que pueden llamarse puramente funcionales. Entre las causas específicas figuran: pólipos, bolas de pelo o cuerpos extraños intraluminales; leyomioma intramural; lesiones inflamatorias, ya benignas o malignas, del hígado, páncreas, duodeno, vesícula biliar o colon; hiperplasia adenolinfática de origen inflamatorio o metastático; bridas mesentéricas congénitas; variación en el tamaño y relación de los tejidos circundantes; y enfermedad de órganos remotos, por ej., apéndice, corazón, pulmones, riñones o sistema nervioso central. El A. no ha podido determinar ningún factor común que pueda considerarse como causante de los nichos producidos por estados tan variados.

Preséntase una serie de casos típicos. En la mayoría se había sospechado tanto clínica como radiológicamente la presencia de una lesión maligna, pero un repaso de las historias revela que, en general, los hallazgos clínicos no correspondían en gravedad al cuadro radiológico.

Al concluir, cítase la declaración del Dr. Frank Lahey, con respecto a las deformaciones prepilóricas: ". . . . . el no hallar lesión en la exploración operatoria por deberse la deformidad roentgenológica probablemente a espasmo prepilórico es seguramente mejor que descubrir más tarde que la lesión es maligna y que ha pasado la época propicia para la extirpación."

X-Ray Observations Before and After Vagotomy[1]

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VAGOTOMY, THE recently popularized and rather widely publicized surgical procedure designed for the relief of peptic ulcer, has become a subject of considerable controversy. Dragstedt and associates in many recent contributions to the literature are largely responsible for the general interest and the great amount of work being done in this field. This group is most enthusiastic about the results obtained and they have written extensively on the subject; many others have accepted the procedure and report favorable results. Some, on the other hand, have reacted unfavorably and have either rejected the procedure entirely, or have reserved its uses for the very occasional case; many in this group are not only very skeptical, but highly critical of the possible value of the method. The controversy is complicated further by the fact that proponents of vagus resection appear in disagreement on the method of approach to the vagus nerve. The two groups are divided on the merits of the transthoracic and the transabdominal route. The one group contends that complete resection of all fibers can be more easily and more satisfactorily accomplished transthoracically; transabdominal proponents contend that resection by this route is not only not difficult, but that it can be done with complete satisfaction and that it gives the additional advantage of affording an opportunity to study the pathology within the abdomen.

Peptic ulcer therapy has followed this controversial pattern through the ages; many, many methods have been presented over the years, each of which appeared to offer some hope that the final solution of the problem of peptic ulcer cure had been attained. With some, one method has succeeded to a degree; with others, another method has appeared to have accomplished the desired end. None has ever been universally accepted; most have been discarded, and the search for the correct answer goes on.

Time has been the most important factor in proving the efficacy of any method of medical or surgical care. Time will prove the worth, or the deficiency, of resection of the vagus nerve and will undoubtedly permit the proper evaluation of vagotomy. Dragstedt's first cases were treated five years ago and have been carefully followed since. To date he has lost none of his enthusiasm for the method; his ardor has not cooled; his interval reports speak for themselves. As radiologists, we have no particular role to play in this surgical argument. However, we do have the opportunity to observe the ulcer patient and to study the results. Through this we may be helpful in arriving at a solution of the problem.

It has been our privilege to have observed 40 patients who have been subjected to vagotomy. Statistics of the group are presented in summary as a report for general information, while case reports are limited to the roentgen findings noted in these patients. The surgery was performed by several different surgeons working in four different hospitals: Dr. A. M. Vaughn of Mercy Hospital, Chicago, has 25 patients in this group.

The average age of the patients was forty-four. The youngest patient was twenty-five, the oldest sixty. Six were forty or under, six were over fifty, and the remainder between forty and fifty. Vagus resections were done, for the main part, on patients who had given a chronic or recurrent ulcer history. The average duration of symptoms was ten years, with 2 patients giving

[1] Presented at the Thirty-third Annual Meeting of the Radiological Society of North America, Boston, Mass., Nov. 30–Dec. 5, 1947.

twenty-year histories and 2 a history of only one year, 8 five years or under, and 9 over fifteen years. Complaints varied widely; all had had one or more of the various types of ulcer management with transitory relief followed by periodic recurrence. None had complete, permanent relief. Complications of peptic ulcer were encountered in several patients. Eight had had severe gross hemorrhage and all of these had had two or more periods of bleeding; one other gave a history of a single hemorrhage. The others, according to the histories, were free of hemorrhage. Six of the patients had had previous surgery due to ulcer: 3 were operated on for acute perforation, and 3 with obstruction had had gastro-enterostomy from six to thirty years previous to vagotomy. The over-night gastric secretion averaged 550 c.c. preoperatively and 200 c.c. postoperatively, with a preoperative maximum of 1,770 c.c. in one patient and a minimum of 60 c.c. in another. Free acid averaged 50° with a preoperative maximum of 113° and one postoperative 18°. The insulin hypoglycemic reaction showed a preoperative acid rise, with none postoperatively.

Vagotomy by the transthoracic approach was done in 10 instances and transabdominally in 30. Eight gastro-enterostomies and two gastric resections were done at the time of the vagus operation. Results, while not entirely conclusive, have been very favorable. The time interval between surgery and recent studies, however, is not sufficiently long to warrant a definite stand. Eighteen months is the longest postoperative interval in the group; many are well over one year, and some between six months and one year.

Results, according to the patient's estimate, were entirely satisfactory in most of the cases; minor complaints were registered by 10 patients and there were 3 apparent failures. Postoperative complaints included diarrhea of varying severity, usually for a short period, but rather prolonged in 5 patients, and in 1 case lasting several months; abdominal distention, particularly after heavy meals; bloating in several; halitosis of high grade in 3 patients; pain in the chest wall in several of the transthoracic patients; and severe colicky abdominal pain for short periods in 2 patients. Most of the complaints have been of minor character and of only short duration. In a few the improvement has been slow, but for the main part it has been satisfactory to the patient. The striking thing about the procedure is the almost immediate and complete relief of any and all of the usual manifestations of ulcer. Distaste for certain foods almost entirely disappeared; relief of pain and distress in the interval between meals was complete; night distress, frequently a most serious complaint and one which caused much loss of sleep, was no longer noted, and most patients bragged of the fact that they now could eat everything.

These have been our observations in patients who have undergone the operative procedure known as vagotomy. We as radiologists should be familiar with the vagotomy controversy and with the pertinent clinical and laboratory findings and thus know better what to expect when asked to study one of these patients. It is the intent of this presentation to demonstrate some of the occasionally startling and often paradoxical roentgen findings encountered. It is rather striking to have a patient for fluoroscopic study appear well, state that he feels fine, has no distress, eats everything, sleeps well and has gained weight since operation, and then to find, on barium study, that his stomach is markedly distended, containing considerable quantities of retained food material and retaining opaque material almost completely, in some instances over a twenty-four hour period; to have great difficulty in visualizing the duodenal bulb and, when it is demonstrated, to observe a marked deformity; sometimes to find evidence of a persisting ulcer crater in the complete absence of pain or tenderness on direct palpation. Yet this is what can be expected when dealing with post-vagotomy patients.

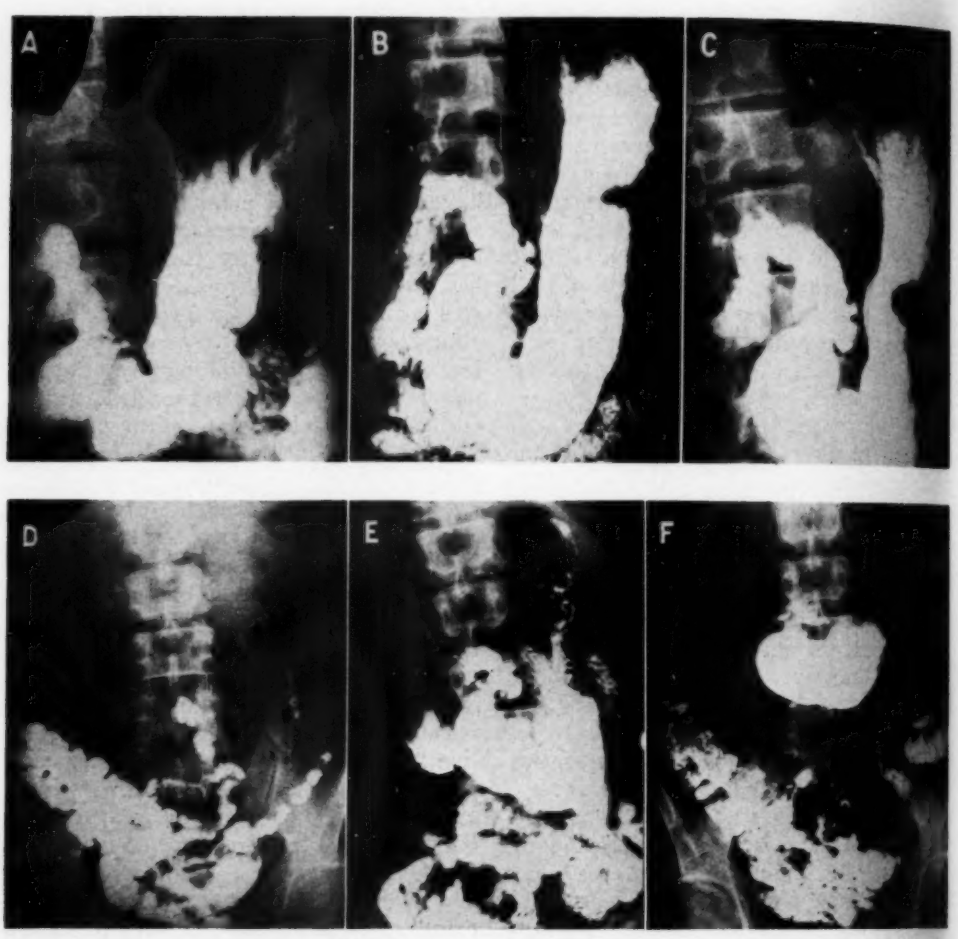

Fig. 1. Case 1. A. Immediate preoperative film, showing the duodenal cap markedly deformed. Peristalsis was hyperactive. B. Two weeks postoperative. Cap deformed and rigid. Stomach atonic. C. Fourteen months postoperative. Cap deformity unchanged. Slight peristaltic action.

D. Preoperative five-hour study. Stomach empty. Opaque material in the terminal ileum and ascending colon. E. Five-hour study, two weeks postoperative. Marked gastric retention. Opaque material in the small bowel but not in the colon. F. Five-hour film fourteen months postoperative. Gastric retention marked. Improved small intestinal activity indicated by barium in ascending colon.

CASE REPORTS

CASE 1 (Fig. 1): G. W., a 53-year-old Chinese, gave a history of recurrent ulcer manifestations over a period of eighteen years, three gross hemorrhages, and an acute perforation six months previous to our first examination. Transthoracic vagotomy was done four days after this. Preoperative study showed a persistent duodenal bulb deformity in a hyperactive stomach. Postoperative studies over a period of fourteen months showed the bulb deformity more marked and rigid, and peristaltic action very definitely limited. Five-hour films showed marked postoperative retention of barium and of solid material. The patient has no complaints, eats everything, and is well satisfied with the results of his operation.

CASE 2: E. J., a 44-year-old white female, gave a five-year history of peptic ulcer, two massive hemorrhages, and frequent recurrence of epigastric distress despite medical management. Preoperative study revealed marked deformity of the duodenal bulb, hyperperistalsis, and moderate five-hour retention. Transabdominal vagotomy was done and four months later the patient returned for further study. The duodenal deformity persisted, the stomach was slightly distended, peristalsis was almost absent, and

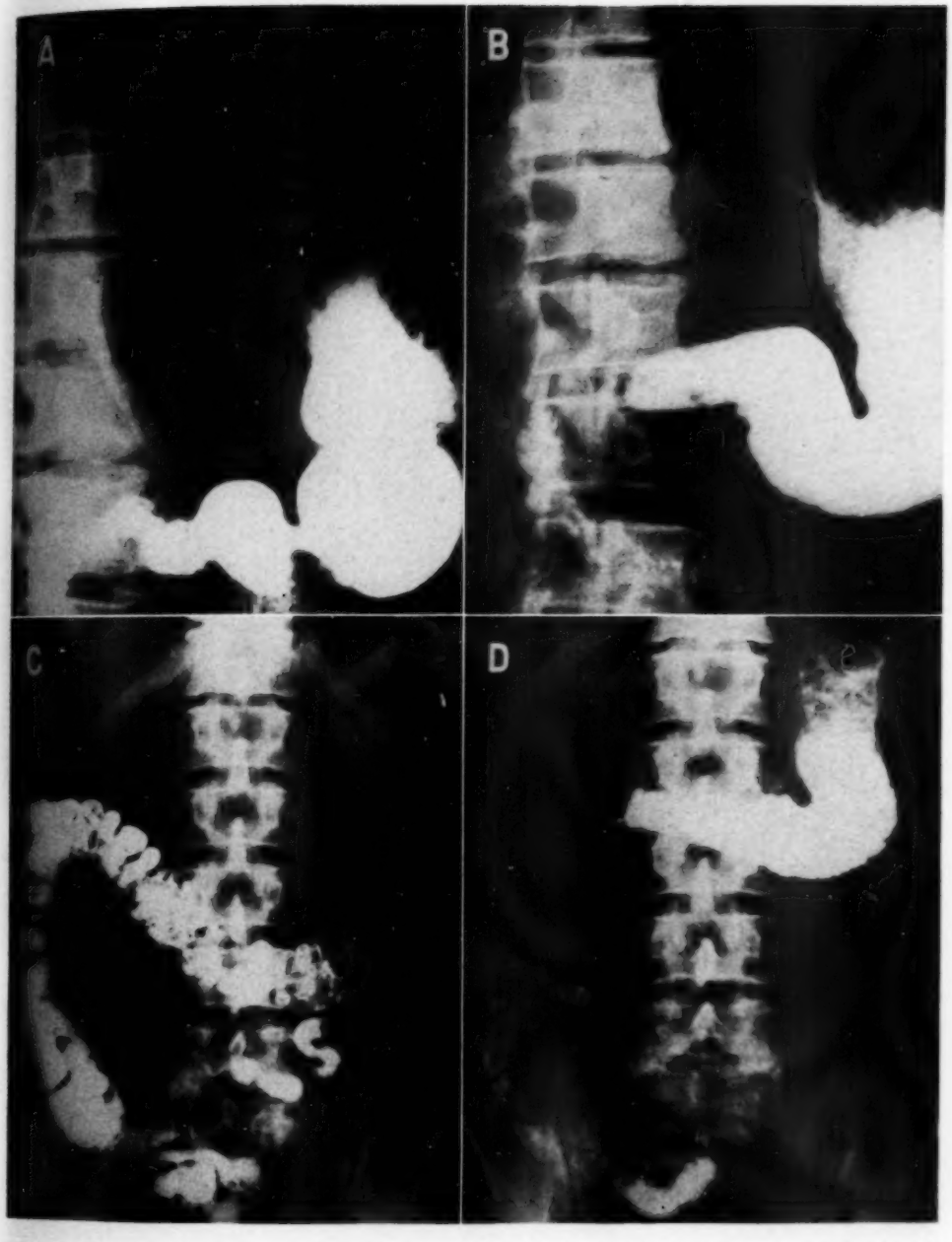

Fig. 2. Case 3. A. Preoperative film showing marked duodenal defect. Hyperactive peristalsis. B. Three months postoperative. Atonic, distended stomach with evidence of solid material retained in fundus. Bulb not visualized. C. Preoperative five-hour study. Stomach completely empty. Peak of barium column in distal transverse colon. D. Five-hour film three months postoperative. Almost complete gastric retention. No apparent peristaltic waves. Cap not filled. Very small quantity of barium in small bowel, none in colon.

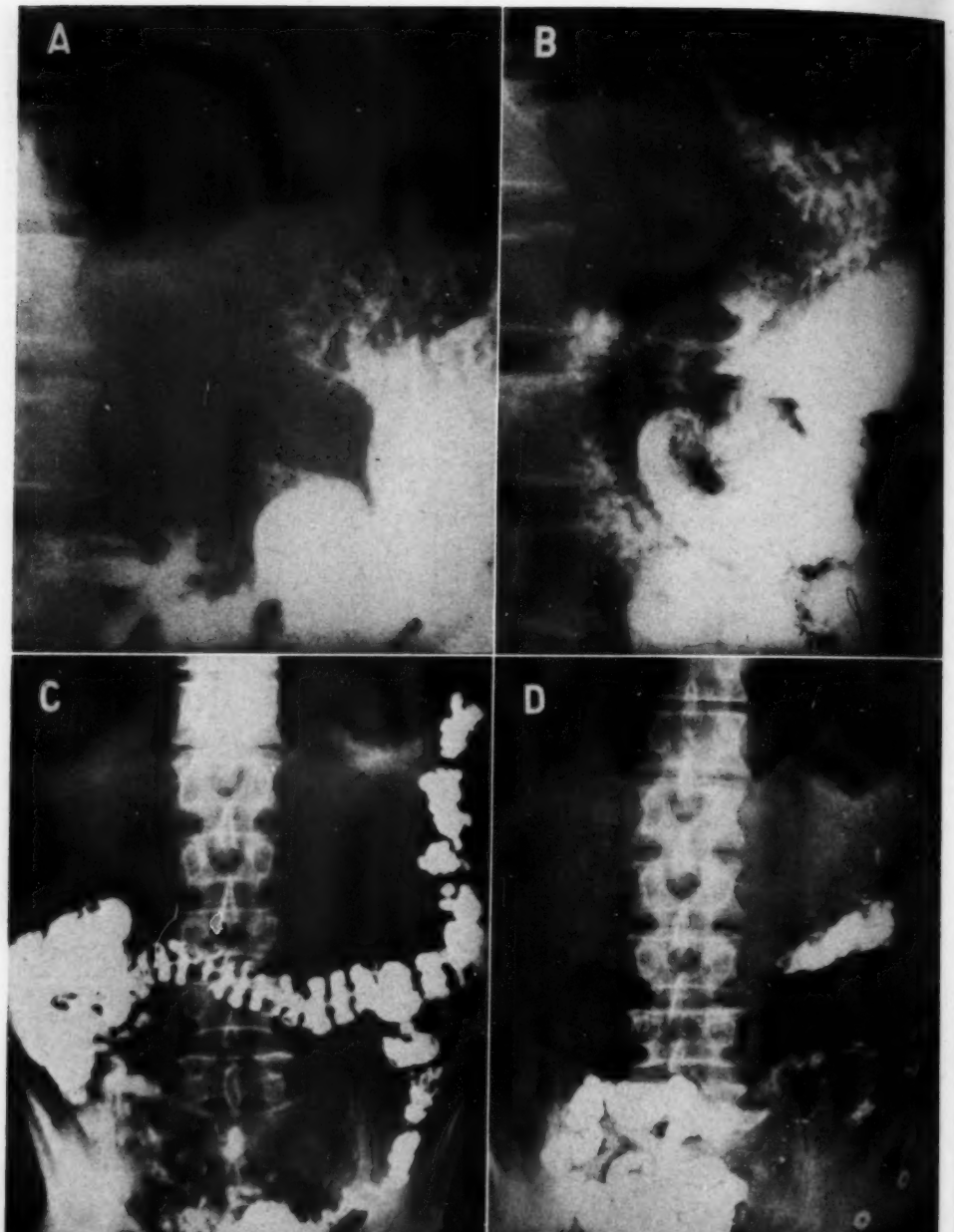

Fig. 3. Case 4. A. Preoperative film. Duodenum markedly deformed. Hyperperistaltic action. B. Six months postoperative. Deformity unchanged. Slight peristalsis. C. Preoperative five-hour film. Stomach completely empty. Peak of barium column in sigmoid colon. D. Six months postoperative. Five-hour retention. Barium low in small bowel, but none in colon.

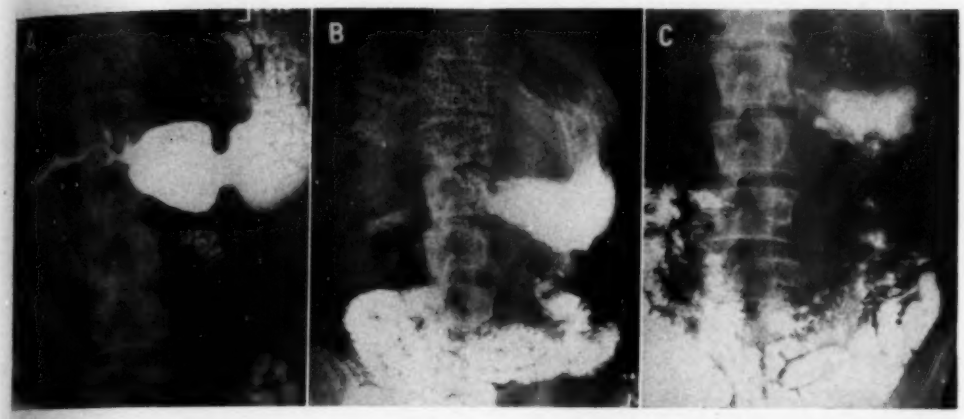

Fig. 4. Case 10. A. Preoperative film. Marked deformity of duodenal bulb. Deep peristaltic waves. Five-hour fluoroscopy showed the stomach empty. B. One month postoperative. Five-hour gastric retention marked. Very little material passed through the pylorus, most of it passing through the gastro-enterostomy opening. C. Six months postoperative. Five-hour gastric retention not as marked as at one month.

the five-hour retention remained unchanged. Passage of the radiopaque material in the small intestine was much slower than at the first examination. There has been no return of any ulcer symptoms.

CASE 3 (Fig. 2): M. G., a 60-year-old white male, gave a history of over twenty years, with two severe hemorrhages. Preoperative study showed a duodenal bulb deformity with hyperperistalsis and no five-hour retention. Transabdominal vagotomy was done and the patient returned three months later. The stomach at this time was slightly distended; peristaltic waves could not be seen, and it was impossible to fill the duodenal bulb. There was marked five-hour retention. In spite of these x-ray findings, the patient had no complaints.

CASE 4 (Fig. 3): J. R., a 59-year-old white male, gave a twenty-year history of peptic ulcer. He had had several severe hemorrhages and an acute perforation four months preceding vagotomy, which was done transabdominally. Preoperative diagnosis was duodenal ulcer with complete emptying of the stomach at five hours. A six-month postoperative study showed the duodenal deformity more marked, peristalsis less active, and a slight gastric retention. Small-intestinal activity was slow. This patient has had the first real relief of epigastric distress over a period of several years; he states that he eats and drinks everything without trouble.

CASE 5: A. J., a 40-year-old white male, had had stomach trouble over fifteen years, with frequent recurrence of symptoms in spite of rigid observation of medical management. The preoperative diagnosis was duodenal ulcer. Transabdominal vagotomy was done, and the patient returned at three- and six-month invervals for observation. There was no apparent change in the appearance of the stomach and duodenum on fluoroscopy, but at both examinations there was marked postoperative retention with a definite delay in the passage of barium through the small intestine. The patient no longer experiences any gastric distress and feels fine.

CASE 6: M. C., a 42-year-old white male, gave a two-and-a-half-year history of severe gastric pain and three gross hemorrhages. The preoperative diagnosis was duodenal ulcer with a hyperactive stomach. Transthoracic vagotomy was done, and the patient returned at one and seven months for further study. One month postoperatively the duodenal bulb was smooth in outline, peristalsis was sluggish, and there was marked gastric retention. At seven months, the stomach emptied completely. The patient feels fine.

CASE 7: H. C., a 46-year-old male, gave a fourteen-year history of duodenal ulcer. Transabdominal vagotomy with posterior gastro-enterostomy was done. Two weeks postoperatively the local reaction about the site of the stoma was severe and most of the barium passed through the duodenum. There was considerable five-hour retention. At one year, the stomach emptied very rapidly, containing only a small amount of barium after one hour. This patient has no complaint of distress, sleeps well, and has gained several pounds in weight.

CASE 8: J. M., a 28-year-old white male, gave a five-year history of severe gastric distress, particularly at night. The night pain was so severe that he was unable to sleep properly and consequently was not able to carry on his work. Preoperative interval studies revealed progressing duodenal deformity, but no retention. Transabdominal vagotomy with posterior gastro-enterostomy was done, and the patient was immediately relieved of all distress. Postoperative studies showed marked five-hour retention of barium and of solids. This patient has had complete relief of all symptoms; he is able

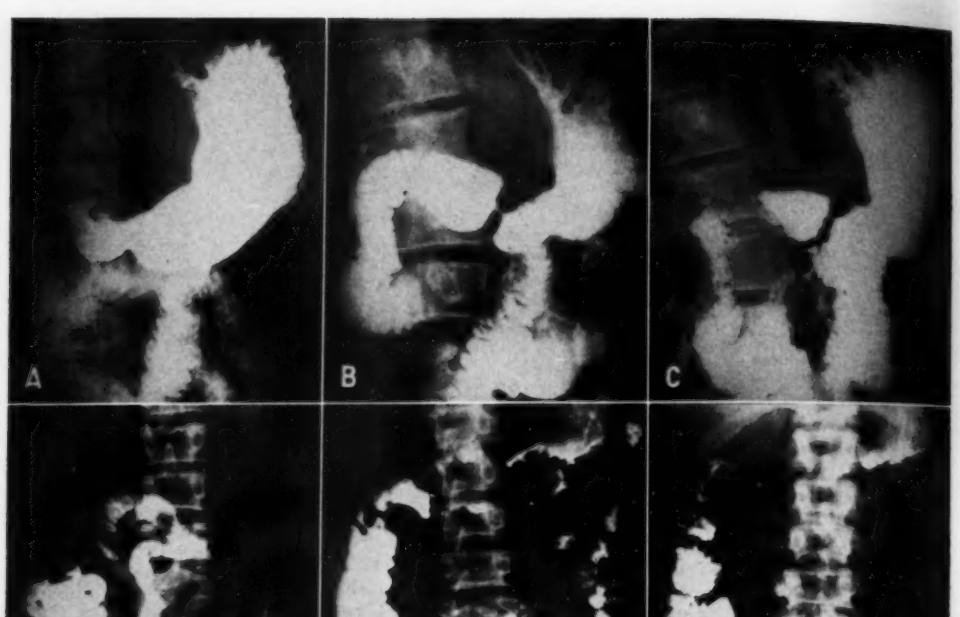

Fig. 5. Case 11. A. Preoperative film. Lesser curvature, prepyloric defect. B. Three months postoperative. Pylorus smooth; pylorus and gastro-enterostomy both functioning. Evidence of solid retention in the fundus. C. Eight months postoperative. No change. D. Preoperative five-hour film. Stomach empty. E and F. Five-hour films, three (E) and eight (F) months postoperative. Slight gastric retention.

to eat everything, sleeps well, and has gained considerable weight.

CASE 9: C. D., a 47-year-old white male, gave a short history of only one year. He had had two rather severe hemorrhages and his distress persisted in spite of medical management. A diagnosis of lesser curvature gastric ulcer had been made elsewhere, before our study. The niche could not be demonstrated at the time of our examination. Gastroscopic observation, however, showed very small prepyloric, lesser curvature ulceration. Transabdominal vagotomy with posterior gastro-enterostomy was done. Three- and ten-month postoperative studies showed slight gastric retention, with no evidence of ulcer. The patient has been completely relieved of gastric distress since operation.

CASE 10 (Fig. 4): V. B., a white male 25 years old, gave a four-year history of symptoms unrelieved by medical management and a marked weight loss. The preoperative diagnosis was duodenal ulcer without retention. Transabdominal vagotomy with gastro-enterostomy was done. Postoperative study after nine months showed no appreciable change except for slight gastric retention, but the patient is completely relieved.

CASE 11 (Fig. 5): A white male of 45 years gave a ten-year history of gastric disturbance. Preoperative diagnosis of lesser curvature gastric ulcer was made outside the hospital. Vagotomy with partial gastrectomy was done because of the possibility of a malignant ulcer. The patient made an uneventful recovery and feels fine in spite of x-ray evidence of distention of the stomach with marked retention of solids.

CASE 12 (Fig. 6): A 26-year-old white male with a five-year history of upper abdominal pain showed a lesser curvature gastric ulcer well above the incisura. This did not respond properly to medical management, and transthoracic vagotomy was done. The ulcer niche completely disappeared after three months, and this was thought to be an excellent result. Four months later, however, when the patient returned for re-examination, a small niche was again seen near the site of the original lesion. This has responded to dietary management. This is one of the three failures encountered in this series.

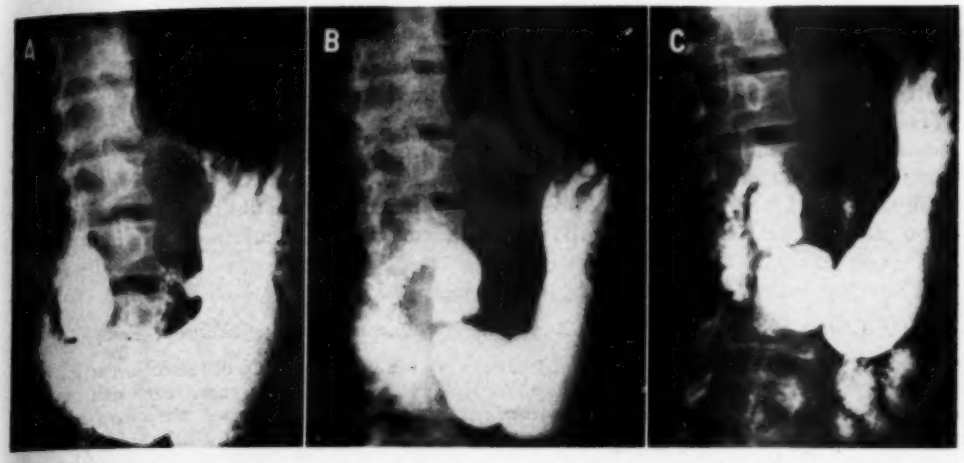

Fig. 6. Case 12. A. Preoperative film. Lesser curvature gastric ulcer niche. This had persisted in spite of rigid medical management. B. Three months postoperative. Lesser curvature lesion entirely cleared. C. Eight months postoperative. Recurrence.

SUMMARY

Vagotomy for peptic ulcer has now been done over a five-year period, with favorable results to date. In a series of 40 cases, there were 3 in which the treatment was unsuccessful, in 2 instances due to the highly nervous, unstable type of patient and in the third probably to an incomplete vagotomy. Thirty-seven patients are entirely satisfied with the result. However, it is our feeling, in view of the roentgen findings, that more time is necessary for a complete evaluation of the method.

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SUMARIO

Observaciones Roentgenológicas Antes y Después de la Vagotomía

Reina considerable discrepancia de opiniones con respecto al valor de la vagotomía en el tratamiento de la úlcera péptica. En vista de esto, se ejecutó un estudio de las observaciones radiológicas en una serie de 40 enfermos vagotomizados, en la mayor parte por historia de úlcera crónica o recurrente. La duración de los síntomas antes de la vagotomía promedió diez años, variando de dos a veinte años. En todos los casos, menos uno, se habían probado uno o más de los varios métodos de tratamiento de la úlcera, con alivio pasajero seguido de recurrencia. Seis enfermos habían sido atendidos con la cirugía por úlcera.

En 10 casos se ejecutó la vagotomía por

vía transtorácica y en 30 por vía transabdominal. Al mismo tiempo se verificaron ocho gastroenterostomías y dos gastrectomías.

Todos los enfermos, menos 3 (2 de tipo inestable y muy nervioso y 1 en el cual la vagotomía fué probablemente incompleta) se aliviaron de los síntomas y se expresaron como satisfechos del resultado al cabo de un plazo postoperatorio que, en algunos casos, llegaba a 18 meses. Sin embargo, se necesita más tiempo para la debida justipreciación del procedimiento, máxime dadas las observaciones roentgenológicas postoperatorias, que comprendieron: continua distensión gástrica, retención del bario, deformidades del bulbo duodenal y hasta signos de persistente nicho de úlcera.

DISCUSSION

(Papers by Palazzo and Schulz; Russell, Weintraub, and Temple; Jenkinson; Furey)

David G. Pugh, M.D. (Rochester, Minn.): Dr. Russell and his associates have noted the need for careful terminology in describing the anatomic portions of the stomach. Much of the apparent discrepancy in the literature is based on misunderstanding. Much that appears in disagreement among various investigators is a matter not so much of difference in roentgenologic interpretation as in pathologic interpretation, especially with regard to the exact location of the lesion.

This is especially true with regard to pyloric ulcers. Differences in definition and terminology also seem to explain the difference of opinion with regard to the malignancy and benignancy of prepyloric ulcers as described by Hampton, on the one hand, and Russell and his associates, Singleton, and Kirklin and MacCarty, on the other hand.

At the Mayo Clinic our pathologists feel that basically a pyloric ulcer is either a duodenal ulcer or a gastric ulcer. They try, if possible, to identify an ulcer in the region of the pylorus as either one or the other. They do not like to make a diagnosis of "pyloric ulcer" unless they find it impossible to determine whether it is duodenal or gastric. That is their opinion; other people disagree, and I can't settle the dispute.

Although most roentgenologists are extremely interested in the treatment of peptic ulcers by means of vagotomy, most of us have not had experience over a sufficient period of time to allow us to arrive at any sweeping conclusions. My experience has been similar to that of Dr. Furey. I have found it difficult to come to any definite conclusions as to the merit of the procedure. I have always been impressed by the sudden and spectacular relief from pain that these patients manifest. There are afferent nerve fibers in the vagus nerve. The sensory innervation of the stomach is not well known, but it may be that when the vagus is resected, the stomach is thereafter anesthetic, and this may explain the sudden relief from pain. On the other hand, the relief from pain may be due to rapid lowering of the acidity in the stomach or to the lessened motility.

Dr. Palazzo and Dr. Schulz have discussed a most interesting group of tumors occurring in the digestive tract. My experience with regard to these tumors involving the esophagus and stomach is comparable with that of these investigators. We have been especially interested in the leiomyomas of the small intestine. In a period of six years—from 1939 to 1945, inclusive—10 patients were operated on at the Mayo Clinic because of leiomyomas of the small intestine. The preoperative roentgenologic diagnosis of leiomyoma, or intramural tumor, was made in 7 of these cases.

A leiomyoma of the small bowel is a most difficult tumor to detect roentgenologically. Every loop of the bowel must be palpated carefully under fluoroscopy; otherwise, lesions of this type will never be found.

I wish to show slides of two cases of leiomyoma of the small bowel which demonstrate their roentgenologic appearance.[1] The first is a spot roentgenogram of two leiomyomas which were found in a segment of jejunum. It was only after considerable palpation and manipulation that these lesions were identified and the roentgenologic diagnosis of leiomyoma was made. I have also slides of another leiomyoma of the small intestine. We see in the large film a rather indefinite defect. In the spot film the tumor can be seen. The tumor has caused some intussusception in this case which made the lesion more conspicuous than such lesions are ordinarily. If you discount the intussusception, you will see that this type of tumor would be extremely difficult to detect. Careful palpation of the bowel is necessary in order to find this type of lesion and then to be absolutely sure that it is there.

I know of no way in which benign tumors can be definitely distinguished from malignant tumors in this group. When malignant tumors are removed surgically, we never know whether the patient has really been cured. Recently I examined a patient who had had a partial gastrectomy in 1924 for leiomyosarcoma of the stomach. The patient returned this year, twenty-three years after the first

[1] Slides were shown at this point.

operation, with a leiomyosarcoma involving the stomach near the anastomosis, diagnosed roentgenologically and proved surgically. It is not possible to say whether this is a recurrence or a new lesion; it is probable that it is a recurrence.

Walter A. Russell, M.D. (*closing*): We agree with Dr. Pugh that there is a definite need for precise terminology, and feel that a consistent attempt should be made by all radiologists to use the same terms, in the hope that eventually the surgeons and pathologists will do the same.

With respect to the discussion of pyloric ulcers, there is very little which we can do to break down the opinion at the Mayo Clinic. At our own hospital there is no disagreement between roentgenologists, surgeons, and pathologists with respect to the presence of pyloric ulcers. Two representative pyloric ulcers have been shown on one of our slides. These lesions are usually small, deep, and "buckshot" in type; often it is difficult to find the openings of these ulcers, even with the specimens in the hand.

William L. Palazzo, M.D. (*closing*): It seems that Dr. Pugh's experience has been much the same as ours in that his demonstration of the spindle-cell tumors throughout the gastro-intestinal tract is comparable. However, he does seem to have had some better success in demonstrating those in the small intestine.

We hope in the future, after the teachings of Schatzki, to be able to discover more of these lesions in the small intestine while they are still small, by means of the small bowel enema. We believe that this procedure should have further application in the study of all types of tumors of the small bowel.

Just one additional point, and that is that tumors of muscle-cell origin are more common in the esophagus, small bowel, and large bowel. In the stomach the larger tumors, especially malignant ones, prove to be at least 50 per cent of the time of neurogenic or fibrous tissue origin.

David G. Pugh, M.D.: I think that we are all pretty much in agreement. I do want to repeat that we do find ulcers at the pylorus. It is just that our pathologists, when they examine the specimens, do not designate the lesions pyloric ulcers. According to them, the ulcers are either duodenal or gastric.

Trichobezoar or Hair Ball[1]

A Case Report

JOHN DAY PEAKE, M.D.
Mobile, Ala.

THE ORIGIN OF THE term bezoar as a designation of foreign substances in the stomach, the early history of trichobezoars, or hair balls, and the superstitions associated with them comprise an interesting study, for which one is referred to the classic paper by Matas (9). The subject of bezoars has also been comprehensively reviewed by DeBakey and Ochsner (5). Their collected series numbered 311 of all types and included 171 trichobezoars, to which they added another, making a total of 172 authentic cases reported to 1938. The number has since been added to by Collins (3), Summey and Borzell (13), Levy and Smith (8), Harris (6), Lear and Brady (7), Miller and Kert (10) (3 cases), Sarnoff and Sarnoff (12), Clayton-Mitchell (2), and Watt and Harner (14). The case to be recorded brings the total to 184.

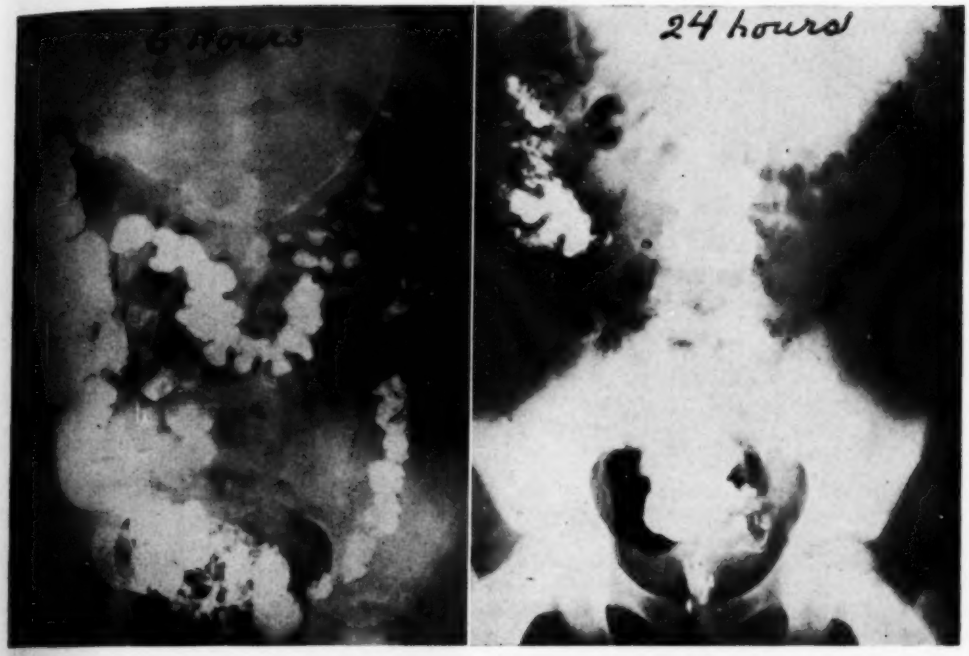
Most gastric hair casts are discovered in females between ten and thirty years old. The patients usually have long hair, and in most instances it will be found that the habit of hair eating, or trichophagia, became established at an early age. DeBakey and Ochsner believe that there probably exists some neurogenic or psychogenic background to account for this practice.

The symptoms and clinical findings are not characteristic. After the hair ball has reached sufficient proportions to cause gastric irritation, there may be nausea, loss of appetite, dyspepsia, headaches, epigastric pain, and mild anemic symptoms. With increase in size, pain becomes more severe, the patient is able to eat less, and there may be blood in the stools. If the hair ball becomes large enough, symptoms of obstruction may develop. For the diagnosis, a history of trichophagia and the presence of an upper abdominal tumor are significant. Other masses, as an enlarged spleen, enlarged or floating kidney, cysts of the liver, spleen, or kidney, and tumors of the omentum, pancreas, stomach, and colon must be ruled out.

Fig. 1. Barium-filled stomach with large intragastric and intraduodenal mass producing a negative shadow. There is an associated penetrating ulcer of the lesser curvature.

According to DeBakey and Ochsner, the first correct roentgen diagnosis of a hair ball in the stomach seems to have been made by Kaufman in 1911. Another early preoperative diagnosis was made by O'Brien (11) in 1918. The intragastric mass produces an irregular negative

[1] Read by title at the Thirty-third Annual Meeting of the Radiological Society of North America, Boston, Mass., Nov. 30–Dec. 5, 1947.



Figs. 2 and 3. Barium retention in and on the intragastric mass at the end of six and twenty-four hours.

shadow, which can often be seen to move within the barium-filled stomach. Peristalsis is usually absent and the gastric air bubble is frequently obliterated. The six-hour film shows the barium caught on the surface of the hair ball, and this appearance may persist at the end of twenty-four hours or longer. In this connection the suggestion is offered that the stomach be filled with air at the time of the six-hour and twenty-four-hour films in order to obtain a better double contrast of the hair ball and gastric mucosa. This was not done in the case reported here for fear of rupturing an associated penetrating gastric ulcer.

The only treatment is surgical. This aspect is covered in the papers of Matas and of DeBakey and Ochsner. Recurrence is rare; Bennett (1) reported a case.

CASE REPORT

A ten-year-old girl was referred to us for investigation of a tumor in the upper abdomen. She had had the usual childhood diseases, with no complications, and had undergone no operations other than tonsillectomy two years earlier. The family history was not significant.

The child was not acutely ill but for the past several years had failed to gain weight and strength; her appetite was poor and she suffered from mild indigestion, constipation, and headaches. For the past few months she had complained of increasing upper abdominal pain with nausea, and occasional vomiting. She stated that she felt full and could eat very little at a time. The mother reported the presence of a tumor in the upper abdomen for more than a year, increasing in size within the last month. No history of eating hair was obtained until after the x-ray examination, when, on direct questioning, the mother stated that at times, when the child became nervous, she would bite her hair.

The appearance of the patient was relatively normal, and her mental attitude was good, though she showed moderate nervousness. Her skin was pale, and her long brown hair was worn in plaits down her back. Her fingernails were short. Ears, eyes, nose, and throat were normal; there was no lymph node involvement, and examination of the chest was negative. Abdominal inspection disclosed a visible mass in the left upper quadrant, firm and partially fixed. There was mild tenderness over the mid epigastrium. The liver, kidneys, and spleen were not palpable.

A blood count showed 4,100,000 red cells, 15,000 white cells (44 per cent polymorphonuclears, 38 per cent lymphocytes, 2 per cent monocytes, 16 per cent eosinophils), 70 per cent hemoglobin. The stools contained hookworm ova but no hair, fibers, or blood. Urinalysis was negative.

Fig. 4. Hair cast of stomach and duodenum after removal.

On a plain film of the abdomen there was an oval shadow in the epigastric area which could not be differentiated from the spleen or left kidney. A barium enema study showed good filling of the colon and revealed no polypoid defects. The upper abdominal mass was shown to be extrinsic to the filled colon. The evacuation film demonstrated a normal mucosa, with no defects.

A gastro-intestinal series showed no esophageal lesion. A small gastric air bubble was demonstrable. The first swallow of barium entering the stomach hesitated at the cardia and then divided, passing by a large, slightly mobile intragastric mass (Fig. 1), which cast a negative shadow. The patient was able to take only 4 oz. of barium. The size of the stomach was normal; no peristaltic waves were observed. On the lesser curvature was a defect typical of a penetrating gastric ulcer. The duodenal bulb was never well filled and there was an extension of the intragastric shadow through the pylorus into the bulb, but no obstruction. Moderate gastric tenderness and rigidity were noted. The six-hour-film (Fig. 2) showed a large intragastric and intraduodenal shadow, with an intermingling of barium; the major portion of the barium was in the lower ileum, cecum, and ascending colon. At twenty-four hours the stomach shadow was similar to that in the six-hour film, but less dense, and the remainder of the barium was in the ascending colon and rectum.

A roentgen study of the chest showed no abnormalities.

The diagnosis was: Trichobezoar; gastric ulcer, penetrating type; hookworm infection.

On Jan. 3, 1947, gastrostomy was done by Dr. C. H. Ross and Dr. H. W. Gray. A black foreign body, with foul odor, conforming completely to the outlines of the stomach and duodenum (Fig. 4), was removed. Postoperative recovery was rapid, and the patient left the hospital in excellent condition.

The pathologist described the operative specimen as a trichobezoar composed of dark hair and conforming in size and shape to the inside surface of the stomach and duodenum. The part corresponding to the greater curvature measured 12.5 cm., with a diameter of 5 cm., and the portion extending into the cardia of the stomach 12 × 3.5 × 3 cm. The weight was 275.5 gm.

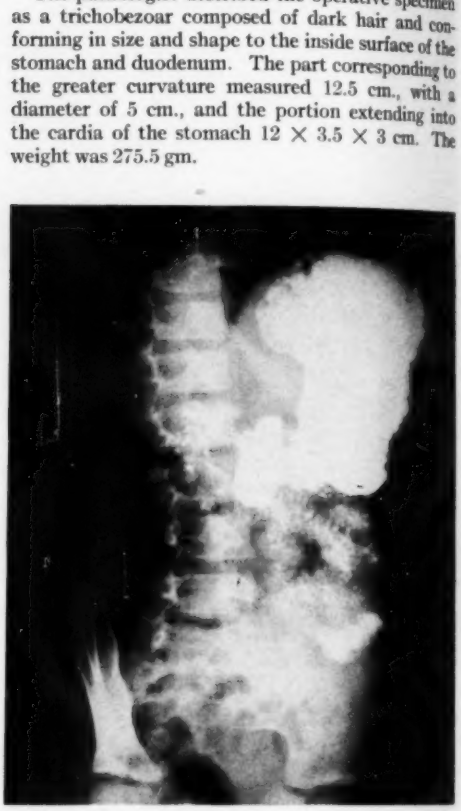


Fig. 5. Stomach and duodenum relatively normal following operation.

A follow-up gastro-intestinal study was done four and one half months after surgery, at which time barium entered the stomach readily, filling it completely. The size and shape were normal, as was peristalsis. A small defect was still present on the lesser curvature at the site of the old gastric ulcer (Fig. 5). The duodenal bulb filled completely and emptied normally. The six-hour film showed no gastric retention; barium was in the low ileum and cecum, and as far as the first third of the transverse colon.

SUMMARY

A case of trichobezoar is reported, complicated by a penetrating gastric ulcer and hookworm infection.

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SUMARIO

Tricobezoar o Bola de Pelo

Comunícase un caso de tricobezoar, complicado con una úlcera gástrica perforante y uncinariasis. La paciente era una niña de 10 años, con antecedentes de tricofagia y tumor palpable en el hipocondrio izquierdo.

El examen radiológico reveló una gran tumefacción intragástrica, con bario entremezclado en la película de seis horas. La bola de pelo extraída al operar se conformaba exactamente a los contornos del estómago y duodeno. Medía 12.5 cm. a lo largo de la gran curvatura, extendiéndose otros 12 cm. al cardias.

Cancer of the Thyroid[1]

PROFESSOR DR. LEONARDO GUZMAN

Director of the Institute of Radium, Santiago, Chile

IT HAS BEEN STATED that radiation is only exceptionally useful in the treatment of carcinoma of the thyroid. According to Crile and Crile (1), "the rare scirrhous carcinomas, the sarcomas, and the totally undifferentiated carcinoma-sarcomas have not been cured by surgery and, with the exception of the lymphosarcomas, do not respond to radiation therapy." With this we cannot agree. As a result of our experience in the National Radium Institute, in Santiago, Chile, we believe that, properly employed, either x-rays or radium may contribute effectively to the cure of all types of thyroid cancer or at least to prolongation of life in cases otherwise hopeless. A similar view has been expressed by Dr. Alvaro Covarrubias, Professor of Surgery in the University of Chile, who has had a large experience with diseases of the thyroid (2).[2]

The series of cases upon which our observations are based comprises various types of thyroid cancer, as will be shown subsequently, including scirrhous carcinoma with invasion of adjacent tissues. In none of these cases was complete surgical removal of the tumor possible.

With a suitable technic, advantage can be taken of the favorable conditions offered by the thyroid for radiotherapy. In the first place, it is a relatively superficial organ; in the second, because of its form, it permits cross-irradiation without excessive exposure of the skin, since multiple ports may be used or, if radium is employed, it can be so applied that radiations from several sources cross at the level of the thyroid, insuring a relatively high tumor dose. Furthermore, the capillary network surrounding the lobules affords the rich vascularization which is highly important for the initial radiation effect. After the first phase of congestion, we may assume a sclerosis, with obstruction of the vessels, resulting in the death or incarceration of the neoplastic cells. Actually the vascular endothelium first becomes edematous, then is destroyed, and finally is replaced by fibrous scar tissue, as in an irradiated angioma. To this effect is added the direct action of the radiation upon the cancer cells. It may be that, in certain cases with a survival of several years, actual sterilization of the neoplastic growth has not been obtained, but the result is attributable rather to the firm fibrous reaction that incarcerates the malignant cells, interferes with their nutrition, and prevents their proliferation.

In the treatment of thyroid carcinoma, the statement of Lacassagne (4) should be borne in mind, namely, that actually all living elements are radiosensible, and that no cell and no human being will survive irradiation sufficiently prolonged or intensive. In cancer of the thyroid, we are generally dealing with a neoplasm of slow growth and a high degree of differentiation (Broders' Grade I). Prolonged irradiation is therefore necessary in the majority of cases, though in the rapidly growing solid anaplastic tumors, corresponding to Broders' Grade III or IV, treatment must, of course, be more intensive and completed in a shorter time. In other words, we must follow the principle of the school of Regaud, Coutard, and Lacassagne, "adapting the chronology of the treatment to the life history of the cancer process."

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[1] Presented at the Thirty-second Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1–6, 1946.

[2] Jüngling of Stuttgart (3) says that the malignant goiter has its place among the radiosensitive carcinomas. He refers to Schädel as taking advantage of this fact as a means of diagnosis, since carcinoma will yield promptly to radiation, while simple goiter will not. He also quotes statistics in support of his views.

In no instance in our series do we believe that the patient's condition was made worse or that the life span was shortened by radiotherapy. On the contrary, it is our conviction that the treatment was invariably beneficial. Except in two cases, ulceration was healed and dysphonia, dysphagia, and pain were alleviated. Nor do we believe that irradiation stimulates metastasis. In most of our cases with metastatic spread, this was already present before treatment was instituted. In Case V (see below) a metastasis in the humerus appearing three years following irradiation of the thyroid yielded to roentgen therapy. Similarly, in Case VI, a metastatic tumor of the mediastinum, discovered a year after irradiation of the primary lesion, disappeared after further irradiation. In a third case (Case III) post-irradiation lymph-node metastases were successfully treated by dissection followed by radium application, and the patient remains well at this writing.

In the National Radium Institute, there were seen 10,412 patients with cancer and allied diseases between August 1930 and Jan. 31, 1946. Among these were 63 with cancer of the thyroid gland, 46 women and 17 men. The highest incidence was between the ages of forty and sixty, accounting for 34 of the cases. One patient was under twenty years of age and 5 were seventy or over. One case appearing in our files as a cancer of the thyroid, but in which that diagnosis was incorrect, is included here merely for the clinical lesson to be learned from it.

A man of forty-five years was seen in November 1930, complaining of a swelling in the thyroid region and loss of weight. Because of a history of syphilis, he had been treated with the arsenicals and the mercurials. As the mass had continued to increase in size, he was referred to the Institute for irradiation. There he received 2,850 r in thirty-five days. Two months later there was an extensive necrotic ulcer in the irradiated area. This was dressed daily and healed in another two months. The patient died in 1932 and autopsy showed "tertiary visceral syphilis" with multiple gummas in the viscera, bone rarefaction and periostitis, diffuse fibrous tissue in the irradiated region, and gummas throughout the soft tissues of the body.

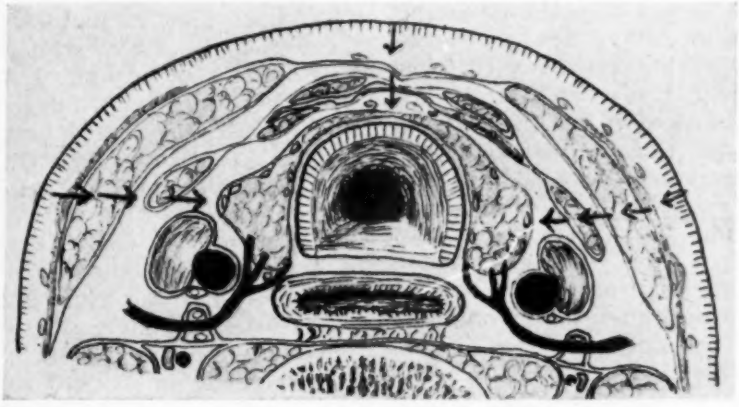

Fig. 1. Transverse section of the neck through the thyroid region. The arrows point to the thyroid.

In short, it would appear that this patient was suffering from a tertiary syphilis rather than a cancer. The error in diagnosis was due to failure to perform a biopsy and emphasizes in a striking manner the importance of that procedure as a guide to treatment.

In our series there was one malignant giant-cell tumor, one paraganglioma, one polymorphous sarcoma, and one endothelioma. In 12 cases biopsy was not done, and in 1 the histologic findings were not clear. The carcinomas which constituted

the remainder of the series were divided as follows: papillary adenocarcinoma, 23, or 36.5 per cent (Crile's figure for this group was 17.2 per cent); solid carcinoma 16, or 25.4 per cent; trabecular adenocarcinoma, 4, or 6.3 per cent; scirrhous carcinoma 3 or 4.7 per cent.

So far as they are capable of invading and destroying the thyroid capsule, recurring, and giving rise to metastases, the so-called malignant adenomas are to be classed as cancer. We have accordingly grouped them with the solid carcinomas when they resembled these and with the papillary tumors when the appearance was dendritic.

Clinically, all the cases treated by irradiation, with two exceptions, were of Group III as described by Portmann (5), *i.e.*, the tumor had invaded the thyroid capsule or extended beyond it.

Eighteen cases developed on the basis of previous goiter. One patient had been operated upon five years and another (Case IV) seven years earlier for goiter. We assume that in these cases a small thyroid lobule was intentionally left by the surgeon to guard against myxedema or that a small aberrant lobule remained between ligatures. There were 3 toxic goiters. In 2 cases toxic phenomena were present without previous evidence of goiter. In 1 instance a thyroid lobule in the tonsil underwent malignant change and later cancer of the thyroid developed (Case VIII).

SYMPTOMATOLOGY

In 4 cases a tumor appeared only after dysphonia was clearly evident; in 3 cases dysphagia preceded the development of a palpable tumor, and in another dyspnea with dysphonia. Dysphonia may be due to invasion of the larynx, as in 3 of our cases, and dysphagia to involvement of the laryngeal vestibule. In 2 cases the arytenoids were invaded and in a third the epiglottis was involved.

It is worthy of emphasis that the general condition of the patients remained excellent except in a few rapidly progressive cases (one of sarcoma and two others).

TREATMENT

Though all the patients in this series were operated upon, it would not be accurate to describe the treatment as combined surgery and irradiation, since in all except two cases the operation was very limited, the greater part of the lesion being left *in situ*. In other words, the patients came to us with the complications inherent in traumatized cancer. Because of this, our series does not lend itself to statistical comparison with those recorded by observers elsewhere.

Thirty-six cases were treated by x-rays, 23 of these prior to June 1941. Of the latter group, 1 has survived eleven years, 1 nine years, 1 seven years, 1 six years, 3 five years, 4 four years, 3 three years, and 3 two years. If the single paraganglioma (Case I) is omitted, leaving 22 cases treated up to June 1941, the five-year survival rate is 27.7 per cent, or 6 out of the 22 patients.[3] Omitting one other case (Case II) in which we believe the operation was complete, we still have a five-year figure of 25 per cent representing only advanced cases with partial operation.

We consider an adequate x-ray dose as ranging between 5,000 and 8,000 r, at 200 kv., 10 ma., 2 mm. Cu filtration, and 50 cm. distance. This dose is delivered through two lateral ports, of dimensions determined by the size of the mass to be treated, and a small central port. Each lateral port receives 40 per cent of the total dose and the central port 20 per cent.

Twelve patients were treated by radium prior to June 1, 1943, and of these 3 were alive for more than five years, 1 for eleven years, 1 for eight years, and 1 for seven and a half years. All of these had undergone incomplete operation. Two other patients were alive after four and

[3] Holfelder (6), in his tabulations of malignant struma, showed that of 22 patients with inoperable disease, 3 (13.6 per cent) treated by roentgen rays lived more than five years; of 8 undergoing incomplete operation, only 1 (12.5 per cent) survived more than five years. Pablo Lazarus (7*a*) lists 103 cases operated upon by Eiselberg with only 7 survivals of more than a year, and 15 cases treated by irradiation by Schädel with 4 five-year survivals. Of Schädel's cases, 2 were inoperable, while of our series 34 were inoperable.

three years, respectively, and 3 after two and a half years. Of 10 patients treated by radium up to September 1941, 1 lived only a short time; another lived two and a half years; 3 were controlled for five years or more and 1 for four years. One patient (Case III) was treated by roentgen rays in 1936 and had a second recurrence treated by radium in 1944.

The radium is applied in the form of a radium collar, containing several radium sources of 8 to 10 mg. each, spaced 4 or 5 cm. apart. The distance from the skin is 4 or 5 cm. and the filtration 2.0 mm. of gold-platinum. Treatment is continuous over a period of eight to twenty days, depending upon the individual case. We have avoided radium puncture for fear of entering the vessels and causing hemorrhage or infection.

Dr. Stanford Cade, in his book on radium therapy of malignant tumors (8) mentioned 3 cases of thyroid carcinoma treated by application of a radium collar, with survivals of seven, five, and four years. In none of these cases was there lymph node involvement.

Twelve patients in our series were not treated, for various reasons. Several refused treatment; in others metastatic invasion of the lungs had occurred, and 2 were referred for surgery.

CASE HISTORIES

CASE I: A woman aged 50 years was first seen by us in 1931, with a history of a nodule in the neck for two years. This had ulcerated, and examination showed infiltration of the left arytenoid. Biopsy of the neck nodule and the arytenoid lesion showed large pyramidal cells resembling ganglion cells. From March 16 to April 26 the patient received roentgen therapy, 6,900 r, and the infiltration decreased. She was not again heard from until June 1936. At that time we received a report stating that there was a retractile scar in the neck, on the right side, that there had been edema of the forearms and hands, but that x-ray examination had revealed no lesion. In December 1939 and in April 1940, the patient wrote that she was losing weight. She died of cancer in December 1941.

CASE II: A woman of 46 was operated upon in December 1936 for a mass in the thyroid which was described pathologically as a trabecular adenocarcinoma with areas of vesicular colloid adenoma. She remained well until October 1940, when enlarged lymph nodes appeared in the right cervical region. On extirpation, these showed cylindrical epithelioma. Roentgen therapy was given postoperatively, a dose of 4,500 r between Nov. 21 and Dec. 11, 1940. The patient was still in good condition in January 1945.

CASE III: A 50-year-old man was admitted in December 1936 complaining of dysphonia of three months duration. Operation in November 1936 had revealed a papillary adenocarcinoma with mitosis, which was partially removed. Some areas of calcification were present. Roentgen therapy was given from Dec. 9 to 22 for a total dose of 3,600 r, and the patient remained well for a period of years. He was again seen in January 1943 with a hard mass in the left side of the neck. Operation was done and the histologic diagnosis was papillary adenocarcinoma. Postoperative roentgen therapy was given and the patient's weight increased from 70 to 83 kilos.

The following year (March 1944) the patient was again operated upon for enlarged lymph nodes in the right carotid region and again the diagnosis was papillary adenocarcinoma. A radium collar was applied from March 31 to April 3 and the patient remained well until October 1944, when we last examined him.

CASE IV: A 50-year-old woman was admitted in December 1940. She had been operated upon for goiter in 1933. In January 1940 she had discovered a tumor in the neck, and biopsy in October showed this to be a papillary carcinoma. She was given roentgen therapy from Dec. 4 to 27, 1940, receiving a total dose of 4,800 r. In June 1945 there was a recurrence with dysphonia, "cornage," and deviation of the larynx by hard masses. Roentgen therapy was given from June 14 to July 17, for a total dose of 7,500 r, and the patient was well when last seen, on March 14, 1946.

CASE V: A woman of 42 years had a tumor of the thyroid removed in 1914. There were successive recurrences in 1924, 1931, and 1933. Histologic examination in 1931 was reported as showing only normal tissue, but in 1933 the diagnosis was papillary adenocarcinoma. Operation at that time was limited to curettement, and roentgen therapy was instituted; 6,800 r was given and the tumor disappeared.

In March 1936, the patient complained of pain in the right shoulder and roentgen examination revealed metastatic lesions in the right humerus and the adjacent rib. A dose of 3,800 r was given to the humerus. Symptoms disappeared and the patient gained weight. She remained well until June 4, 1940. Death occurred in October 1940, but the cause is not known.

CASE VI: A man, 70 years old, experienced dysphonia in 1937. A year later there was enlargement of the thyroid and when the patient was first seen there was a mass in the left half of the gland extending toward the thorax, with fixation of the

left hemilarynx. Roentgen therapy—8,400 r—was given in April but in August 1940 dysphonia persisted. A film obtained at this time showed a round mass in the posterior mediastinum, and a dose of 9,600 r was given to this region (June 1940), after which the voice and the general condition improved. The patient was last seen in 1942 in good condition.

CASE VII: A woman of 48 years gave a history of repeated curettage for menorrhagia and metrorrhagia. Since 1914 she had noticed in the right side of the neck a small nodule. In 1939 this began to increase in size and there was a loss of 7 kilos in weight. In May 1940 the tumor measured 12 cm. in transverse diameter and projected for a distance of 6 cm. A piece of the mass was removed and examination showed areas of interlacing connective-tissue fibers, moderately indurated, surrounding soft strumous regions showing multinucleated giant cells. The colloid vesicles were atrophied. The diagnosis was giant-cell sarcoma. Further treatment was contraindicated by the patient's condition and she died within a few months.

CASE VIII: A woman of 54 years was operated on in 1941 for a tumor of the left tonsil, which was found to contain malignant thyroid tissue, covered by normal pavement epithelium. In July 1943, a thyroid tumor was removed and was found to be a papillary carcinoma. This tumor recurred in 1945 and was again removed, the diagnosis being "papillary epithelioma with karyokinesis and atypical cells." Roentgen therapy was given postoperatively (October 1945), and the patient remains well to date.

The interest of this case lies in its evolution and the question it poses: Was the tumor metastatic? Perhaps it could be considered as close to the type described by George Crile, Jr., as aberrant thyroid, with multiple primary lesions arising simultaneously in the thyroid and in the aberrant thyroid tissue.

SUMMARY

A series of 63 cancers of the thyroid is reported, of which 18 developed on the basis of a previous goiter. All had invaded or extended beyond the thyroid capsule. Operation had been done in all, but with two exceptions the surgical procedure was very limited and the greater part of the cancer remained *in situ* when the patient was referred for irradiation.

Thirty-six cases received roentgen therapy. Among 22 thus treated before June 1941, there were 6 surviving five years or longer. Twelve patients were treated by radium prior to June 1943, and of these 3 were alive for eleven, eight, and seven and a half years, respectively. The figures are minimal, since it is possible that some of the patients who could not be followed still remain well. Irradiation, whether by x-rays or radium, was invariably beneficial. With but two exceptions, ulceration was healed and dysphonia, dysphagia, and pain were alleviated. In no case was the condition made worse nor was the life span shortened.

The following conclusions are reached:

1. In view of the frequency of thyroid cancer arising in goiter, all goiters should be removed, at whatever age they occur, unless they represent a merely temporary compensation of thyroid insufficiency.[4]

2. Cancer which has not invaded the thyroid capsule—*i.e.*, which is not adherent to the deeper structures—and has not metastasized should be treated surgically.

3. Thyroid cancer of whatever histologic type is susceptible to palliation or cure by irradiation properly applied. In view of the fact that radioactive iodine (I^{131}) is not stored by the most malignant varieties of thyroid cancer cells, we believe that x-rays and gamma rays still have their place in the treatment of cancer of the thyroid.

4. Treatment of choice in inoperable cancer of the thyroid is irradiation by roentgen rays or radium: 6,000 to 9,000 r delivered through three ports over a period of six weeks or continuous application of a radium collar for twelve to fifteen days.

5. In view of the fact that in one case lymph node involvement followed apparently complete removal of an early cancer of the thyroid, postoperative irradiation appears advisable.

6. No myxedema was observed in the series reported here.[5]

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[4] As a result of this practice, the death rate from cancer of the thyroid in Switzerland has been reduced from 3.2 to 0.9 per cent (*7b*).

[5] In one case seen in private practice, first treated by x-rays in 1933 following an incomplete operation, and again in 1935 for a recurrence, myxedema occurred in 1937. This responded to treatment with thyroidin and iodine, and the patient is in good condition thirteen years following the initial irradiation.

7. The macroscopic anatomy and the histologic structure of the thyroid gland are factors contributing to the good results reported above.

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SUMARIO

Cancer del Tiroides

En esta serie de 63 cánceres tiroideos, 18 tuvieron por base un bocio anterior. Todos habían invadido o se habían extendido más allá de la cápsula de la glándula. Todos habían sido operados, pero con dos excepciones el procedimiento quirúrgico había sido muy limitado, y la mayor parte del cáncer permanecía *in situ* cuando el enfermo fué enviado para irradiación.

Treinta y seis casos recibieron la roentgenoterapia. Entre 22 tratados en esa forma antes de junio, 1941, hubo 6 sobrevivencias de cinco años o más. Doce enfermos fueron tratados con radio antes de junio, 1943, y 3 de ellos estaban vivos a los once, ocho y siete años y medio, respectivamente. Esas cifras son mínimas, pues es posible que algunos de los pacientes perdidos de vista todavía continúen bien. La irradiación, ya con los rayos X o con el radio, resultó invariablemente beneficiosa. Sólo con dos excepciones, la ulceración sanó y se aliviaron la disfagia y el dolor. En ningún caso empeoró el estado o se acortó la duración de la vida.

Se sacaron las siguientes conclusiones:

(1) Vista la frecuencia con que el cáncer tiroideo se sobrepone al bocio, todos los bocios deben ser extirpados, a cualquiera edad a que se presenten, a menos que representen una compensación puramente temporal de una insuficiencia tiroidea.

(2) El cáncer que no ha invadido la cápsula tiroidea—es decir, que no está adherido a los tejidos profundos—ni formado metástasis, debe ser tratado quirúrgicamente.

(3) El cáncer tiroideo de cualquier tipo histológico es susceptible de paliación o curación con la irradiación.

(4) El tratamiento de elección en el cáncer inoperable del tiroides es la irradiación con los rayos X o el radio: 6,000 ó 9,000 r entregados por tres puertas durante un período de seis semanas o continua aplicación de un collar de radio durante doce a quince días.

(5) Visto que en un caso se presentó invasión ganglionar después de una extirpación aparentemente completa de un cáncer temprano del tiroides, la irradiación postoperatoria parece conveniente.

(6) En esta serie no se observó mixedema.

(7) La anatomía macroscópica y la estructura histológica de la glándula tiroidea representan factores que contribuyeron a los buenos resultados aquí descritos.

Notching of Ribs Without Coarctation[1]

PHILIP BATCHELDER, M.D.,[2] and ROBERT J. WILLIAMS, M.D.[3]

Providence, R. I.

NOTCHING OF THE ribs by dilated and tortuous intercostal arteries, visible by x-ray, as a sign of coarctation of the aorta, was first described in 1928 by Roesler (2) (then of Vienna, now of Temple University, Philadelphia). The first notice in regard to the roentgenographic appearance in English was given by Railsback and Dock (1), in 1929, who found descriptions of notching in articles written long before the discovery of the x-ray. They noted the absence of mention of the appearance in several x-ray texts but were apparently unaware of the independent work by Roesler, which had appeared in the previous year in the German literature.

Since that time several articles on coarctation have appeared in medical journals and in textbooks, all of them calling attention to the notching of the ribs, which, if present, was thought to be *practically* (italics are the authors') pathognomonic of coarctation. In Roesler's (3) book on roentgenology of the heart, for example, he says (p. 398): "The erosion of the ribs is the most unequivocal roentgenographic sign.... These erosions are multiple, bilateral and limited to the caudal margins of the dorsal portions of the ribs. They are limited to the right hemithorax when the seat of coarctation is proximal to the origin of the left subclavian artery."

We have observed a patient with notching of the *left* ribs only, without coarctation of the aorta.

CASE HISTORY

A 38-year-old, single, white male was admitted to the Rhode Island Hospital with dyspnea, orthopnea, and cyanosis. He had been known to have "heart trouble" since the age of six, and activity had been restricted because exercise brought on dyspnea and cyanosis. With care, he had done quite well until about two months previously, when he began to have headaches, loss of appetite, nocturnal dyspnea, and orthopnea. He coughed some, but had no edema or ascites. There was no history of rheumatic fever.

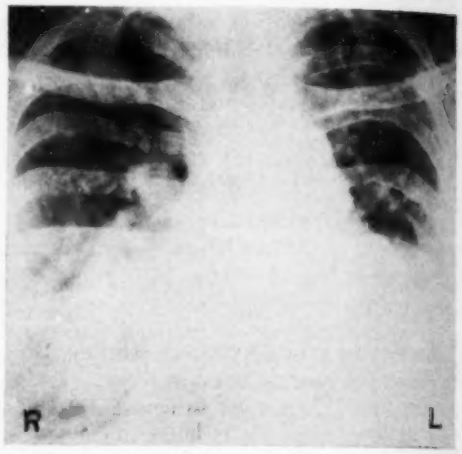

Fig. 1. View of chest showing large heart, congestion at bases of lungs, and notching of left ribs.

Physical examination showed cyanosis and rapid respirations, with dullness at both lung bases. The heart showed a rapid regular rate, increased width to percussion, and a thrill over the apex. No murmurs were present, and the sounds were loud and snapping. The blood pressure in the right and left arms was 110/90 and in the left leg was 145/110. The liver descended about one finger breadth below the costal margin on deep inspiration.

The circulation time was delayed according to several tests. The Wassermann and Hinton reactions were reported negative. The blood showed hemoglobin 112 per cent, red cells 4,960,000, white cells 3,200. X-ray examination revealed a very large heart shadow, engorged blood vessels, and notching of the under edges of the left 5th, 6th, and 7th ribs. The patient failed rapidly and died with signs of cardiac failure and terminal pneumonia seven days after admission. The autopsy findings pertinent to this report follow.

Autopsy Report

Autopsy was performed two hours after death. The body is that of a well developed and moder-

[1] Presented at the Thirty-third Annual Meeting of the Radiological Society of North America, Boston, Mass., Nov. 30–Dec. 5, 1947.

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Fig. 2. Photograph of heart and attached aorta showing orifices of intercostal branches, large on the left and normal on the right.

ately obese white man, measuring 176 cm. in length. There is no edema. On section, the subcutaneous abdominal fat is 5 cm. in thickness. The peritoneal and pleural cavities show no abnormality.

On opening the pericardial sac, it is seen that the root of the aorta is situated posterior and to the right of the root of the main pulmonary artery. The left border of the aorta extends to the mid-line of the pulmonary artery. The innominate, left common carotid and left subclavian arteries are identified as arising from the aortic arch in normal position and have a normal distribution. The heart, lungs, and thoracic portion of the aorta are removed together intact. The pulmonary veins are identified as entering the left auricle, and the venal caval as entering the right auricle.

Heart: The weight of the heart with the aorta attached is 775 gm. The tricuspid valve ring measures 10 cm. in circumference, the pulmonic 7 cm., the aortic 10 cm., and the mitral 10 cm. The maximum thickness of the myocardium of the left ventricle is 17 mm. and that of the right ventricle is 17 mm. The heart is large. The epicardium is thin and smooth. There is an increased amount of fat in the auricular-ventricular groove and extending down along the course of the coronary vessels and covering the surface of the right ventricle.

The right auricle and ventricle are greatly dilated and the wall of the right ventricle is thickened (17 mm.). The endocardium of the right auricle is thin and smooth. There is a 1-cm. opening in the foramen ovale which is closed by a valve-like flap. The tricuspid leaflets show no abnormality. The papillary muscles are large. The pulmonary conus measures 2 cm. in length, and its orifice is small, measuring 1.0 × 1.5 cm. The pulmonary conus is lined by a thick, gray, tough fibrous membrane, measuring from 2 mm. to 3 mm. in thickness. This begins at the orifice of the pulmonary conus and extends up to the base of the pulmonary cusps. The pulmonary valve has only two cusps, an anterior and posterior one. The cusps are large, with slight diffuse thickening.

The commissure on the right side is obliterated over a distance of 2 mm. by fibrous adhesions. On the pulmonary artery side of the posterior cusp, near its right distal attachment at its junction with the intima of the pulmonary artery, there are two small out-pouchings measuring 3 mm. in diameter. On the pulmonary artery side of the posterior cusp, at its left distal attachment in the groove between the pulmonary artery and the cusp, there is a nodule of gray firm tissue measuring 10 × 3 × 4 mm. It is covered by endocardium and its long axis is in the long axis of the groove between the pulmonary artery and the pulmonic cusp.

The pulmonary artery and its right and left branch are dilated. The main pulmonary artery measures 9 cm. in circumference. Scattered over the intimal surface are numerous 1 to 2 mm. gray-yellow plaques, slightly elevated. The ductus arteriosus is obliterated.

The left auricle is of average size. The endocardium is smooth, gray-white, and opaque. The mitral leaflets show no abnormality except for a few scattered small gray-yellow plaques at their bases. The left ventricle is dilated and the papillary muscles are large. In the anterior and basal portion of the interventricular septum, immediately below the right coronary cusp of the aortic valve and below the adjacent half of the non-coronary cusp, is a large defect in the septum, measuring 2.0 × 2.5 cm. It is roughly oval in shape, having smooth, even margins. The defect extends through the septum into the right ventricle, where it appears immediately posterior to the pulmonary conus and just medial to a tricuspid leaflet. The orifice of the aorta overrides this septal defect, the aorta thus arising from both the right and left ventricle. Approximately one-third of the orifice arises from the right ventricle and the remainder from the left ventricle.

Aorta: The aorta is of average circumference. The mid portion of the ascending thoracic aorta measures 7.5 cm. in circumference, that of the transverse thoracic aorta 6 cm., that of the descending thoracic aorta 4.8 cm., and that of the abdominal aorta 3.5 cm. in circumference. There is no stenosis. The aorta is moderately elastic and shows slight intimal sclerosis. The orifices of the intercostal arteries of the descending thoracic aorta on the left side are dilated, measuring 3 to 4 mm. in diameter, as compared to the orifices of the intercostals on the right side, which are 1 to 2 mm. in diameter. The 5th, 6th, 7th, and 8th left intercostal orifices are the most dilated.

Intercostal Vessels and Ribs: The posterior 15 cm. of the 5th, 6th, 7th, and 8th ribs, with intervening

intercostal muscles and vessels on the left are removed in block, and the 4th, 5th, 6th, 7th, and 8th ribs on the right are similarly removed. On dissection of the intercostal vessels on the left, the proximal 5 to 7 cm. of the 5th, 6th, 7th, and 8th intercostal arteries are irregularly dilated up to 3 to 4 mm. in diameter, are markedly tortuous, and form numerous U-shaped loops. The more distal portions of the arteries are straight and are of small caliber. Where

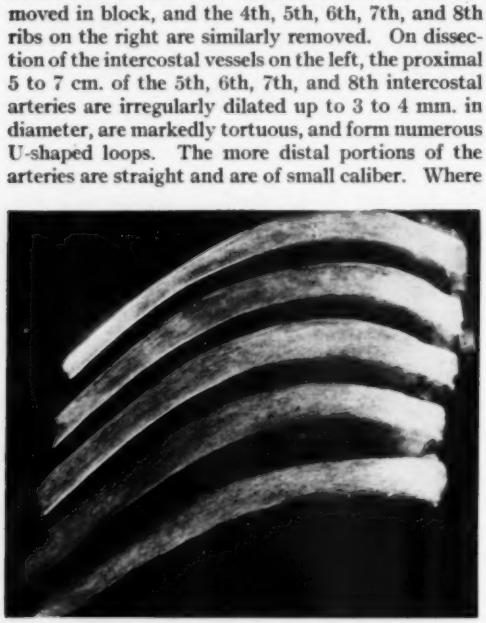

Fig. 3. Roentgenogram of excised right ribs (fourth to eighth), showing normal contour.

the tortuous loops of the arteries are in contact with the inferior border of the ribs, these show smooth shallow depressions which measure up to 1 cm. in diameter and up to 2 to 3 mm. in depth. As many as four of these shallow depressions are identified in one rib. These erosions of the ribs are more marked in the case of the 5th and 6th ribs, less so in the 7th, and still less in the 8th. The tortuosity and dilatation of the different arteries are of corresponding degree. The left intercostal veins are dissected free from the arteries. They follow the course of the arteries and appear slightly dilated as compared to the intercostal veins on the right. Dissection of the intercostal arteries and veins on the right shows them to be straight and of narrow caliber. These arteries and veins measure approximately 2 mm. in diameter in their most proximal portion.

Internal Mammary Vessels: The internal mammary artery and vein on the left and right are dissected. They are thin-walled, straight, and of average caliber.

Lungs: The right lung weighs 550 gm. and the left lung 720 gm. The lower lobes of both lungs are large, red, and rubbery in consistency; crepitation is diminished. On section, they present a red, wet, smooth surface. Except for the region of the apex of the left upper lobe, the remaining lobes are large, soft, and crepitant throughout and on section show a grayish red, moderately wet surface.

In the apex of the left upper lobe is a cystic structure, free of fluid, 6 cm. in diameter. It is composed of three cysts measuring 2 to 3 cm. in diameter. The adjacent cyst walls are contiguous and, where contiguous, the different cysts have a common wall. The walls are 1 to 2 mm. thick and have a smooth, glistening inner surface except for a granular calcified-like incrustation in places. There is a fistulous communication 2 mm. wide between two of the cysts.

Fig. 4. Roentgenogram of excised left ribs, showing notching and tortuous arteries, injected with barium, terminating in normal caliber.

The cystic structure is bounded above by the fused, adherent parietal and visceral pleura and below by lung tissue in which there are many 3- to 10-mm. small cystic spaces. No communication with bronchi is made out.

The *pulmonary arteries* show involvement of their intimal surface by scattered yellow and gray-yellow plaques measuring 2 to 6 mm. in diameter. The bronchi show no significant changes.

Microscopic Findings

Heart: The muscle fibers of the heart are increased in diameter. Their nuclei are large, stain heavily, and have blunt rounded ends. Transverse fragmentation of the muscle fibers is present here and there. There is a focus of extravasation of erythrocytes in one area of the myocardium. Vessels are thin-walled, and the interstitial tissue is slight in amount.

Lungs: In the lungs are focal areas in which the bronchi and adjacent alveolar spaces are filled with neutrophilic polymorphonuclear leukocytes, a few large mononuclears, and an acidophilic precipitate. Throughout all sections the capillaries are engorged with erythrocytes and capillary loops project into the alveolar spaces. In places there is fibrous thickening of the alveolar wall. Only an occasional large mononuclear with a granular brown-yellow pigment in the cytoplasm is present in the alveolar spaces.

In regions, the alveolar walls are thinned out. Only occasional capillaries are visible in the wall, and the alveolar spaces are dilated. There is rupture of

alveolar walls with confluence of several alveolar spaces, forming large dilated air sacs with remnants of the alveolar walls projecting into the lumen.

The small arteries and large arterioles here and there show a marked intimal, relatively acellular, fibrous thickening with varying degrees of narrowing of the lumen.

Sections of the walls of the pulmonary cyst show them to be made up of a dense fibrous tissue with no epithelial lining. Projecting from the inner surface are small single papillary processes made up of dense and hyalinized fibrous tissue, but the surface is smooth for the greater part. There is no pigment and no inflammatory reaction in the wall except for several small foci of lymphocytes.

The alveolar walls adjacent to the cyst wall are thin and in many places are ruptured, with confluence of several alveolar spaces forming large air sacs. Some of these air sacs are lined by a single layer of cuboidal epithelium. In other places, there are fibrosis and thickening of the septa, focal lymphocytic infiltration of the septa, deposition of a black granular intracellular and extracellular pigment. Foreign-body giant cells are here and there associated with the pigment.

Intercostal Arteries: Sections of the intercostal arteries are stained with hematoxylin and eosin, Van Gieson's and Verhoeff's stain for collagen and elastic tissue, respectively. Sections of the right intercostal arteries show no abnormality and are used as controls.

Cross sections of the left intercostal arteries show varying degrees of dilatation. The media varies widely in thickness in the same section of the same artery but is definitely hypertrophied in places.

The intima is thickened here and there, due to increase in collagen and elastic tissue, the former predominating. The thickened intima overlies hypertrophied, normal, or thinned-out media. Hypertrophied to thinned-out media is found in various combinations with normal to fibrotic intima. The internal elastic lamellae is frequently frayed and fragmented. In places, the wall of the artery becomes progressively thin due to decrease in thickness of the media. Finally, the media is completely interrupted with fusion of the internal and external elastic lamellae, and the wall of the artery is reduced to a few strands of collagen and fragmented elastic fibers. This point of fusion of the two elastic lamellae is identified in several instances as the point of origin of a small branch of the intercostal artery. A similar structure, *i.e.*, fusion of the internal and external elastic lamellae with interruption of the media at the point of origin of a branch artery, is identified in the normal right intercostal arteries.

The remainder of the findings are as shown by the pathological diagnosis: congenital malformation of the heart with patent interventricular septum, dextroposition of the aorta, stenosis of pulmonary conus, bicuspid pulmonic valve; cardiac hypertrophy and dilatation; sclerosis of pulmonary arteries and arterioles; dilatation and tortuosity of left intercostal arteries with multiple erosions of ribs; pulmonary emphysema; pulmonary cysts, left apex; healed pleuritis, apex of left lung (fibrous adhesions); chronic passive hyperemia of internal organs; bronchopneumonia.

DISCUSSION

This case shows as its primary pathological feature congenital heart disease of the type called the tetralogy of Fallot. From the roentgenologic point of view, the notching of ribs without coarctation of the aorta assumes primary interest.

The fact of the unilateral distribution of the notching has been difficult to explain on a basis of dynamics. In the usual case of coarctation, the tortuosity and dilatation of the blood vessels are bilateral. An exception to this generalization might be found, as noted by Roesler, when the coarctation was proximal to the origin of the left subclavian. In that case the notching would be confined to the right ribs, while in our case it was confined to the left. Moreover, the dilated vessels on the left were paired and homologous with vessels of perfectly normal diameter at the same levels on the right.

The normal right ribs were removed in a block and the intercostal arteries were dissected. No evidence of dilatation or tortuosity was observed. Because of the very small diameter of the vessels, attempts to obtain visual evidence by injection of opaque material were not successful. One could imagine a situation in which the two sides showed the same condition but in different degree so that notching was visible on one side and not the other. Such was not the case here.

Histologic study of the affected arteries has given no clue to a congenital weakness or developmental anomaly of the arteries themselves. Possibly the right-sided position of the aorta may enter into the explanation, but if so, we do not know how.

It is to be noted that both coarctation of the aorta and the tetralogy of Fallot are congenital cardiovascular anomalies. Previously it has been assumed that the tortuosity was to be explained on a basis

of back-pressure and collateral circulation, and that still seems the most probable explanation in coarctation. The question is raised, without being answered, whether the dilatation and tortuosity may not of themselves constitute a congenital anomaly. At least we have been unable to arrive at any better suggestion for the present case.

It is with considerable reluctance that we herewith record the demise of another "pathognomonic" sign.

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SUMARIO

Crenación Costal Sin Coartación

Comunícase un caso, con hallazgos autópsicos, de cardiopatía congénita perteneciente al tipo denominado tetralogía de Fallot. La característica de primordial interés radiológico fue la escotadura de las costillas, en ausencia de coartación de la aorta. Solo estaban afectadas las costillas del lado izquierdo y a los dilatados y tortuosos vasos de dicho lado correspondían en el derecho vasos de diámetro normal a los mismos niveles. El estudio histológico de los vasos afectados no aportó clave alguna que indicara debilidad congénita o vicio de desarrollo de las arterias mismas.

Obsérvese que tanto la coartación de la aorta como la tetralogia de Fallot son anomalías cardiovasculares congénitas. Solía darse por sentado que podía explicarse la tortuosidad a base de presión de retorno y circulación colateral, y esa explicación parece todavía ser la más probable para la coartación. Sin embargo, se plantea, sin resolver, el problema de si la dilatación y tortuosidad no pueden, por sí mismas, constituir una anomalía congénita. A lo menos, no cabe ofrecer mejor indicación para el caso aquí descrito. A la luz de los hallazgos en este caso, no cabe ya considerar la crenación costal como patognomónica de coartación de la aorta.

Perivascular Injection of Thorotrast and Its Sequelae[1]

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THE PURPOSE OF this paper is to re-emphasize the real and potential dangers of the use of thorotrast as a diagnostic agent. It is hoped by adding to the literature several cases, in which the perivascular injection of thorotrast has produced disabling results, to accentuate the real danger that accompanies its use. Further, we would like to point out the problem of the roentgen diagnosis of thorotrast in the soft tissues when a history of its injection cannot be elicited.

REVIEW OF LITERATURE

An extensive and controversial literature has been built up on the subject of thorotrast since its introduction by Radt in 1929 (15). Excellent reviews have been published by Orr, Popoff *et al.* (11), Stewart and Ghiselin (19), Yater and Coe (23), and others.

Taft (20, 21) has reported volumetric studies on radiation from thorotrast in the tissues and calculated radium equivalents. As a result of his observations, he concluded that the use of 75 c.c. of thorotrast is dangerous, due to the continuous bombardment of the reticulo-endothelial system. Spier, Cluff and Urry (17) reported a case of aplastic anemia following administration of thorotrast and discussed the action of thorium in the body and its role in the production of pathologic changes. In 1936 Selbie (16) described the experimental production of spindle-cell sarcoma in rats by injection of thorotrast. Recently MacMahon (8) reported a case of primary malignant endothelial-cell sarcoma of the liver twelve years after injection of thorotrast; interestingly enough, this same case had been reported two years previously as an example of the harmlessness of thorotrast by virtue of a ten-year follow-up without evident ill effect. Thus, obviously, more than a ten-year follow-up is necessary to absolve thorotrast of carcinogenic properties.

Yater and Coe (23), reporting ten years experience with thorotrast, state that no immediate or remote ill effects of importance have been observed. They caution against perivascular injection only in order to "prevent the formation of subcutaneous nodules and to save veins." Ziffren (24) described two cases of perivascular injection of thorotrast in which the only ill effect noted in two- and three-year periods of observation was localized scarring. Fleming and Chase (4) reported a case in which a patient with symptoms due to thorotrast in the soft tissues of the anticubital space was improved by excision and skin graft. Naegeli and Lauche (10) demonstrated experimentally the migration of thorotrast along the reticulo-endothelial system.

The more recent literature on this subject is predominantly strong against the indiscriminate use of thorotrast as a contrast medium, whereas the earlier publications tend to minimize the hazards in favor of the diagnostic advantages.

Most of the literature decrying the use of thorotrast is based on the systemic effects of the dose (75 c.c.) used in hepatosplenography. In our cases, the untoward results all followed the use of 20 to 40 c.c. in arteriography.

PROPERTIES OF THOROTRAST

As summarized by the Council on Pharmacy and Chemistry of the American Medical Association (22), thorotrast (thorium dioxide sol) is a stabilized solution containing 25 per cent of colloidal thorium dioxide by volume, 19 to 20 per cent by weight, a protective colloid, 16 to 19 per cent by weight, of a dextrin preparation,

[1] From the Radiological Service, Walter Reed General Hospital, Washington, D. C. Presented at the Thirty-third Annual Meeting of the Radiological Society of North America, Boston, Mass., Nov. 30–Dec. 5, 1947.

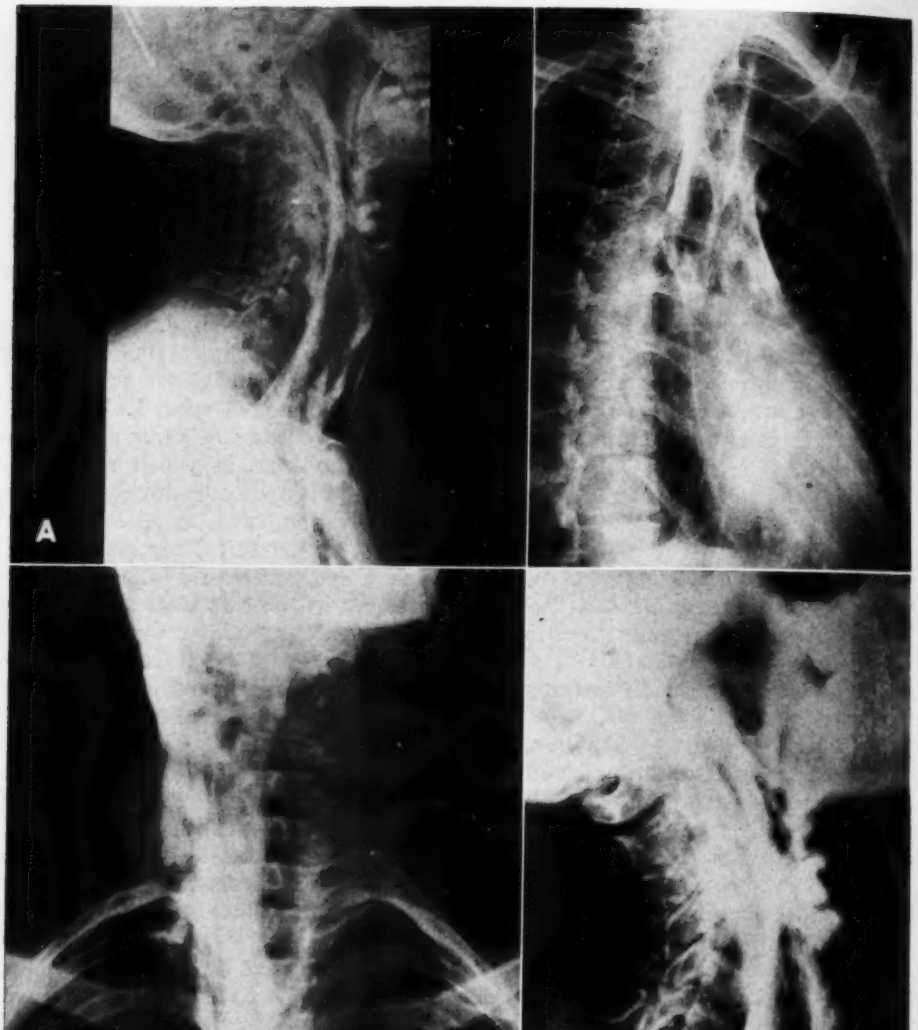

Fig. 1. Case I: White female, age 29, with painful swelling of submaxillary area. No history of thorotrast injection was obtainable. Admission diagnosis: lymphoma

A. July 20, 1943. Widespread linear densities extending from base of skull to root of neck.

B. July 20, 1943. Widespread linear densities in superior mediastinum, surrounding great vessels and extending along the posterior pericardium to within 2 cm. of the diaphragm.

C and D. Dec. 26, 1946, three years after A and B. Marked increase and diffusion of density and tissue involvement. Dysphagia and dyspnea.

and 0.15 per cent methyl-*p*-hydroxybenzoate as a preservative. Its radioactive properties are summarized as follows:

Alpha rays: 25 c.c. of thorotrast are equivalent to a maximum of 1 microgram and a minimum of 0.5 microgram of radium.

Beta rays: Too feeble to be of any physiological significance.

Gamma rays: 25 c.c. of thorotrast are equivalent to approximately 0.3 microgram of radium and are too feeble to be of physiological significance.

Taft (20) found the count from an average dose of thorotrast (75 c.c.) to be equivalent to 1.37 micrograms of radium and states that this approaches the amount (2 micrograms) known to have caused serious radium poisoning.

It is known that the radioactivity of a freshly prepared thorium preparation is not a permanent measure of its emanative properties, as its activity will increase with formation of mesothorium, radiothorium, thorium X, and thorium emanation.

Although alpha particles penetrate approximately only 1 mm., they are by far the most important in terms of direct tissue effects, the ratio of toxicity for tissue of alpha, beta, and gamma rays being as 10,000 to 100 to 1. The wide distribution in tissue of a radioactive substance having a half-life of 1.4×10^{10}, years and emitting highly ionizing particles is at least a serious potential hazard.

Thorotrast has been used chiefly in angiography, urography, hepatosplenography, and myelography. The intravenous dose varies from 25 to 75 c.c. The effects of thorotrast in the recticulo-endothelial system are not within the scope of this report, but it was noticed that in none of our cases could thorotrast be detected in the liver or spleen roentgenographically. Two methods of injecting thorotrast into carotid arteries are in use: direct injection into the surgically exposed artery and indirect injection without exposing the vessel.

CASE REPORTS

CASE I (Figs. 1 and 2): A 29-year-old white female, with a history of epileptiform seizures since 11 years of age, first came to our attention in 1943 with the complaint of a painful swelling in the right submaxillary area which had recurred periodically since 1941. In July 1943 she was admitted with a tentative diagnosis of lymphoma. She was not well endowed mentally and in spite of repeated attempts and considerable correspondence, no history of thorotrast injection could be elicited.

Fig. 2. Case I: Photomicrograph of tissue removed at biopsy from the cervical region. Acellular fibrous tissue, throughout which is scattered coarse, granular refractile material compatible with thorotrast.

Physical examination revealed a nodular tender swelling in the right submaxillary area and a smaller non-tender nodule in the left side of the neck. There was moderate dysphagia.

Roentgenographic examination of the cervical region showed extensive diffuse linear areas of calcific-like density in the soft tissues of the neck, extending from the right mastoid caudally and medially into the superior mediastinum. A diagnosis of myositis ossificans was made.

Biopsy at this time revealed no evidence of lymphoma nor of calcification. The microscopic appearance was that of dense fibrous tissue containing pigment that was considered to be lipochrome.

During the next four months there was a marked increase in the size of the mass in the right side of the neck, and the soft tissues became brawny and indurated. The dysphagia increased markedly, the neck was flexed to the right, and the larynx was displaced to the right and fixed. There was further enlargement of the cervical chain of lymph nodes. Roentgenographic examination revealed an increase in density and extent of the calcific-appearing ma-

Fig. 3. Case II: White female, age 36, with pain and stiffness involving the right side of the neck.
A. Widespread linear and nodular densities in the right side of the neck, extending downward into the right superior mediastinum.
B. Lateral view showing nodular densities and concentration of thorotrast along right carotid sheath.

terial. Biopsy of a left cervical lymph node showed merely hyperplasia.

This case was followed in the Outpatient Department for a period of three years, during which time the condition progressed slowly, steadily, and inexorably. Re-admission became necessary in August 1946 because of the intensity of severe pain generalized over the right side of the neck. The mass at this time was "stony" hard; there was no change in the overlying skin. There was marked edema of the larynx, vocal cords, and trachea causing mild dyspnea and voice change. The dysphagia had progressed to such an extent that the patient was able to swallow solid food only with her neck in extreme flexion.

X-ray examination showed extension of the process down the mediastinum along the posterior margin of the heart to the inferior cardiac border. The density in the neck appeared to extend along the fascial planes. The trachea and esophagus were sharply angulated to the right at the root of the neck. Barium was delayed at the point of angulation when the neck was extended. There was no evidence of increased opacification of the liver or spleen.

Exploration was deemed advisable because of the severity of the dysphagia and dyspnea. At operation the muscle and fascia formed a homogeneous, dense fibrous mass with interspersed yellow-white gritty material. A complete excision was not possible because of the extent of the process and involvement of vital structures. However, the esophagus and trachea were partially freed. After a somewhat stormy recovery, the patient was much improved. The excised tissue was again reported by the laboratory to contain no calcium.

It was at this time that Case II (see below) came to our attention. Accordingly we placed some of the tissue on photographic film and obtained a radioautograph after seven days direct exposure. The tissue was then analyzed at the Los Alamos Scientific Laboratory and found definitely alpha-active. The activity indicated the presence of about 6 to 8 mg. of thorium in the small specimen. Spectrographic analysis revealed the presence of the following elements: thorium, greater than 10 per cent; calcium, greater than 10 per cent; magnesium, greater than 1 per cent; sodium phosphorus and iron, greater than 1 per cent.[2]

After only one month, the dysphagia returned to such an extent that a second palliative operation was necessary. The steady progress of fibrosis of the soft tissues of the neck has continued to such an extent that this patient is now disabled and further surgical excision is not considered feasible.

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[2] We are indebted to Doctor Wright Langham for the quantitative analysis and the qualitative test for alpha activity made in his special low background alpha counter on tissues of Cases I and II.

CASE II (Fig. 3): The patient is a 36-year-old female with neuromuscular symptoms involving the right extremities beginning in June 1942 and slowly becoming more severe. Pneumoencephalographs and electroencephalograms were not conclusive and in December 1945 cerebral arteriography was attempted, but most of the solution was injected into the perivascular tissues.

This patient first came to our attention in November 1946, one month after development of pain and stiffness in the right side of the neck. Roentgenologic examination revealed linear and nodular densities in the right side of the neck almost identical in appearance with those in Case I, but with less extensive distribution.

Pain and stiffness were localized in the right side of the neck posteriorly, with radiation of pain down the right arm. The patient had previously had pain in the back of the neck radiating down the left arm; she said her condition had not changed during the past two years except for new symptoms on the right side. A firm indurated mass, 2 × 4 cm., situated vertically, was palpated in the posterior lateral aspect of the right side of the neck.

At operation, Dec. 6, 1946, extensive fibrosis and yellow-white gritty material were encountered. A granular mass measuring 2 × 2 cm. was excised from the bed of the right sternocleidomastoid muscle. This tissue was also examined at the Los Alamos Scientific Laboratory and the findings were almost identical with those of Case I.

The patient continues to complain of pain and stiffness in the right side of her neck.

CASE III (Fig. 4): A white male, age 51, complained of tingling, numbness, acrocyanosis, and edema of his right hand, leading to a suspicion of Buerger's disease. Arteriography was attempted Aug. 10, 1945. Immediately following the injection, supposedly into the right brachial artery, the patient experienced severe pain just above the elbow on the medial side. Hardening of tissues and nodular masses adjacent to the elbow were noticed in December 1945 and steadily progressed until admission to this hospital. There are tenderness of the involved region, pain and easy fatigability of the arm. The tissue is extremely firm, and nodular masses up to 3 cm. in diameter are present on the medial aspect of the arm just above the elbow. There are slight loss of flexion and about seven degrees loss of extension of the forearm, which results in discomfort in weight carrying. Roentgenologic examination reveals widely distributed calcific-like density in the antecubital tissues with fascial plane distribution.

Due to disability resulting from complications of thorotrast injection into soft tissue, this patient has been given a physical disability retirement from Military Service, which constitutes relief from active duty, with retirement pay and continued military medical attention.

CASE IV (Fig. 5): A white male, age 43, in February 1946 noticed numbness in the right arm and had

Fig. 4. Case III: White male, age 51, with pain, tenderness, easy fatigability, and limitation of motion of forearm. Large nodular masses at the right elbow, widespread linear and nodular densities in antecubital tissues, extending 11 cm. proximally, 14 cm. distally.

slight dysgraphia. By September 1946 he was almost helpless because of dysfunction of the right arm and leg.

Left cerebral arteriography with thorotrast was done on Sept. 14, 1946, and repeated two days later, at which time two injections were necessary, as the first was made into perivascular tissues. Arteriographs and encephalographs were inconclusive and the patient was told he had multiple cerebral thrombosis.

Roentgenologic examination revealed densities similar in appearance to those of the other cases. The opaque substance extended downward into the mediastinum, around the aortic arch and along the wall of the left subclavian artery.

The patient has improved sufficiently to practice law three hours daily. At the site of thorotrast injection in the left side of his neck is a firm mass measuring 5 × 5 × 2 cm. He is conscious that his neck is not normal but symptoms are not disturbing.

CASE V: A colored male, age 19, experienced weakness, confusion, and right hemiplegia two days

Fig. 5. Case IV: White male, age 43, conscious that neck is abnormal but without disturbing symptoms. Linear and large nodular densities in left side of neck, with extension into the mediastinum, along the common carotid and subclavian arteries and around the aortic arch.

after boxing. Bilateral papilledema, hemiplegia, disorientation, negativism, bloody spinal fluid, and a history of injury led to tentative diagnosis of subdural hematoma, which was not confirmed by craniotomy. Left cerebral arteriography was attempted Jan. 13, 1947, but none of the thorotrast was introduced into the artery.

Roentgen examination the following day revealed linear densities along fascial planes of the left side of the neck, extending downward into the mediastinum to within 2 cm. of the aortic arch. There was a striking concentration in the carotid sheath. No symptoms attributable to thorotrast have developed in the five months since the injection.

CASE VI (Fig. 6): During the summer of 1943, the patient, a white female, age 43, had first noticed constant roaring in both ears, which in 1944 became a buzzing sensation that had persisted. She had experienced periodic attacks of vertigo and a sense of suffocation. Neurologic examinations were entirely negative, but cerebral aneurysm was suspected. Electroencephalograms showed a very dysrhythmic record but no focalization. In February 1945, bilateral cerebral arteriography was attempted but was unsuccessful because the thorotrast had been injected into the soft tissues instead of into the carotid arteries.

It was concluded that symptoms were due to psychoneurosis of an anxiety type. Upon admission to this hospital, roentgenologic examination on Sept. 1, 1946, showed a large amount of thorotrast in the soft tissues of both sides of the neck, more marked in the carotid sheaths. The thorotrast extended downward along the superior vena cava to the level of the 7th dorsal vertebra.

Examination revealed a definite rigidity and induration of the soft tissues of the neck which was believed to explain presence of pain at the base of the skull and in the left shoulder.

CASE VII: A white male, age 19, began to have tinnitus in his right ear in the summer of 1944 and in June 1946 had an epileptiform convulsion. Ventriculograms, July 16, 1946, revealed a space-occupying lesion in the left frontal region. Electroencephalographs showed generalized dysrhythmia with left frontotemporal focus. On July 22, 1946, the left carotid artery was exposed and thorotrast was injected directly into it. The arteriographs, however, showed only the external carotid artery. At operation an astrocytoma was removed from the left frontoparietal region.

Routine roentgenograms of the chest for discharge, Dec. 11, 1946, revealed considerable thorotrast in the soft tissues in spite of the direct visualization of and injection into the artery. The thorotrast was concentrated in the carotid sheath and extended down to and partially around the aortic arch.

In the five months the patient was followed, no symptoms developed attributable to thorotrast in the tissues.

DISCUSSION

We have presented 7 cases in which thorotrast has been injected into perivascular tissues during an attempt at arteriography. In 6 of the cases the tissue involved was in the neck, and in all of these the thorotrast ultimately migrated down the fascial planes into the mediastinum. In the remaining case the injection was into the soft tissues of the arm. In 6 of the cases injection was by the indirect method. In one case, however, even after surgical exposure of the carotid artery, perivascular injection resulted.

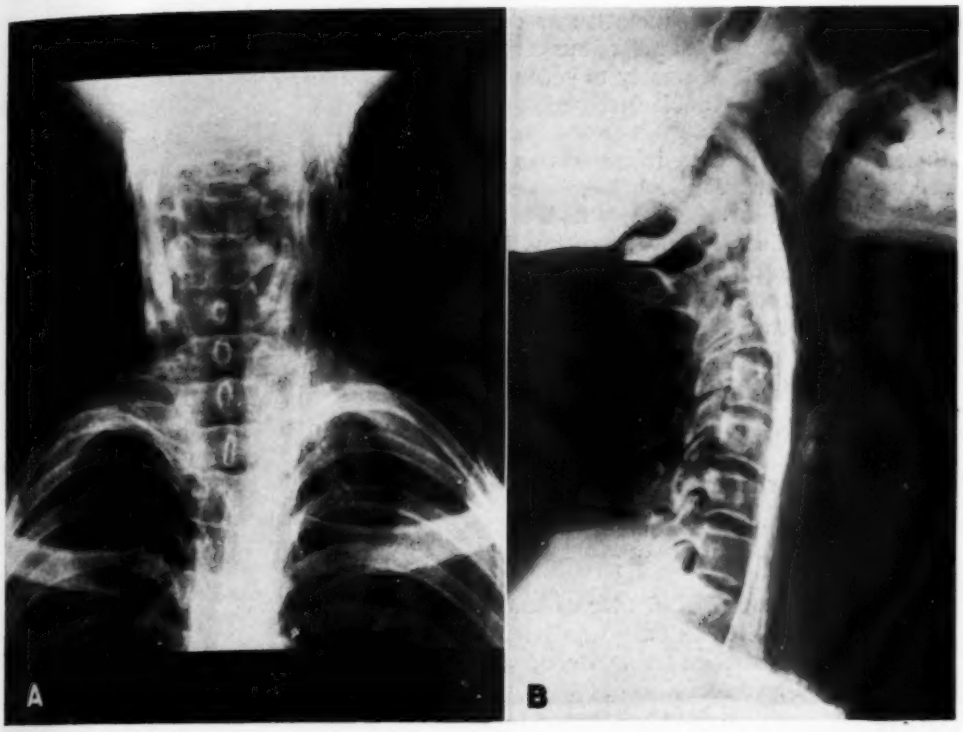

Fig. 6. Case VI: White female, age 43, with rigidity and induration of both sides of the neck, and pain at the base of the skull and in the left shoulder, believed to be due to thorotrast.
A. Nodular densities in right side of neck and linear densities in left side, extending into the mediastinum.
B. Lateral view showing thorotrast concentrated in carotid sheaths.

Symptoms which can be directly attributed to fibrosis and scarring resulting from the presence of this radioactive foreign material in the tissues are present in 3 of our cases. Two patients present no symptoms attributable to thorotrast, but in these cases the period of observation is only three and six months, respectively. One case observed twenty-one months after attempted arteriography presented symptoms believed due to thorotrast and one patient observed for eight months was conscious of abnormality of the neck but denied disturbing symptoms. It is reasonable to assume that after a longer period of time symptoms will become manifest and ultimately result in disability.

The roentgenologic findings in all of the cases are very similar and present no diagnostic problem if a history of thorotrast injection is known. The characteristic irregular calcific-like density in the soft tissues should not be confused with any pathological process except possibly myositis ossificans when large amounts of thorotrast have been injected. Small amounts may be confused with calcified lymph nodes. However, the distribution in fascial planes and the small associated nodular areas should aid in making the diagnosis. The progressive increase in density, widening of the dense fascial planes, extension of the process, and increased nodularity as demonstrated by comparison films are further aids in diagnosis.

The histopathological findings in those of our cases in which biopsy was done are the same as have been previously reported by many authors, *i.e.*, acellular fibrous tissue showing collagenous degeneration and hyalinization with scattered coarsely granular refractile material both interfibrillar and

intracellular. The alpha radiation as determined by Dr. Langham in 2 of our cases is of such magnitude as readily to account for a progressive irreversible destruction of adjacent tissue.

The prognosis of a case in which thorotrast is present in tissue should be guarded, and at no time do we feel it justifiable to consider the radiation from thorotrast in the doses now used as innocuous. We are of the opinion that the potential dangers accompanying the use of thorotrast far outweigh the slight advantage of its greater radiopacity and that its use as a contrast medium in clinical radiology should be discontinued.

SUMMARY

1. Seven cases in which there has been perivascular injection of thorotrast are presented.

2. Symptoms attributed to thorotrast in the tissues in these cases are discussed.

3. The use of thorotrast as a contrast medium should be discontinued.

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SUMARIO

La Inyección Perivascular de Torotrasto y Sus Secuelas

Los peligros que encierra el torotrasto como medio de contraste quedan patentizados por 7 casos en los que fué inyectado perivascularmente al intentar una arteriografía. En 6 se hizo la inyección con el método indirecto y en uno el medio fué inyectado directamente en la carótida, ya exteriorizada quirúrgicamente. En 6 casos el tejido afectado se hallaba en el cuello, y en todos éstos el torotrasto migró por fin hacia abajo por los planos aponeuróticos al mediastino. En el otro caso la inyección fué en los tejidos blandos del brazo.

En 3 de los casos había síntomas im-

putables directamente a la fibrosis y cicatrización debidas a la presencia de la sustancia radioactiva en los tejidos. Opínase que en los demás casos probablemente aparecerán síntomas al alargarse el período de observación.

Roentgenológicamente, el torotrasto perivascular se traduce por sombras calcificoideas irregulares en los tejidos blandos. La irradiación alfa procedente del toro trasto retenido, determinada en 2 de los casos, alcanzó tal magnitud que explicaba fácilmente la destrucción irreversible progresiva del tejido adyacente.

Recomiéndase el abandono del empleo del torotrasto como medio de contraste.

DISCUSSION

(Papers by Amory and Bunch and Batchelder and Williams)

Question: I should like to ask Colonel Amory whether or not any density was demonstrable in the liver or spleen to aid in his diagnosis.

Wm. T. Green, M.D. (Boston, Mass.): I believe that it is not uncommon to have collateral circulation in the tetralogy of Fallot. If that is so, wouldn't the occurrence of notching be due to the same condition? Interestingly enough, as you probably noticed in one of the exhibits, notching of the ribs may occur also as a result of the bony changes in neurofibromatosis.

Merrill C. Sosman, M.D. (Boston, Mass): I thought it rather striking that the pulmonary vessels in Dr. Batchelder's case appeared extremely large as seen on the film. In uncomplicated tetralogy they are usually quite small.

Dr. Batchelder: That was only a week before death, and there was rather marked failure.

R. N. Cooley, M.D. (Baltimore, Md.): I would like to ask Dr. Batchelder if in his case of tetralogy of Fallot there were any pleural adhesions. In the cases which have come to autopsy and operation, particularly in older patients, the intercostal arteries and internal mammary arteries have frequently been observed to be quite large, and they do form a part of the collateral circulation to the lung. Whether this would take place without pleural adhesions is problematic.

Robert E. Gross, M.D. (Boston, Mass.): As to the notching of the ribs in Dr. Batchelder's case, I think there is no question that persons with obstruction of the pulmonary system do develop a collateral circulation just as persons with aortic obstruction do, and this occurs before there are any adhesions between the pleural surfaces. I am certain of this, because in older children with tetralogy of Fallot, exploration of the chest shows a great increase in the vascularity of tissues in the region of the hila and in the mediastinum, which obviously represents collateral circulation. Certainly in older subjects with the cyanotic state—and by that I mean people in their twenties—this increased collateral circulation is a very real thing; enough to increase considerably the surgeon's technical difficulties, as bleeding due to interference with these collateral vessels may be quite troublesome. I believe that such collateral channels can develop before pleural adhesions have appeared. Dr. Blalock and many other surgeons have observed this increasing circulation to the lungs in older people with pulmonary obstructions, and more recently Dr. Bing has obtained actual physiologic measurements which tend to show that as people with pulmonary obstruction get older, they begin to build up a collateral circulation. It is not as great as the surgeon can produce by an operative procedure, but at least Nature is trying to establish a collateral circulation, and I am very much inclined to think that, in the case which Dr. Batchelder describes, the tortuosity of vessels was not due to some inherent disease in the vessels, but to the fact that they carried an increased blood flow as a collateral system. I am surprised that this occurred on one side only, for I think that previous evidence indicates that cyanotic patients develop collaterals on both sides.

Colonel Amory (*closing*): In none of our cases, could thorotrast be detected in the liver and spleen. This may be accounted for by the fact that small doses of thorotrast were used—20 to 25 c.c.—and almost none was injected into the vascular system. It had no way of getting into the liver and spleen. In hepatosplenography I believe that three doses of 25 c.c. each are used on three successive days.

Certainly good technic will minimize accidents during vascular injection, but the substitution of diodrast for thorotrast will prevent disaster when the inevitable slip occurs.

Dr. Batchelder (*closing*): I am sorry that I did not have the complete autopsy report with me which would tell about the matter of pleural adhesions in our patient. All I do have is the summary of the things found, and that does include pulmonary cysts at the left apex, the side on which the lesions were found.

Collateral circulation in tetralogy of Fallot may well take place, but why is it limited to one side?

Protection Requirements of One-Million-Volt (1-Mv.) and Two-Million-Volt (2-Mv.) Roentgen-Ray Installations[1]

CARL B. BRAESTRUP[2] and HAROLD O. WYCKOFF[3]

THE PROTECTION against radiation produced at one million volts and higher has been determined in the past mainly from attenuation data obtained under conditions differing considerably from those found in practice. Most absorption curves have been based on measurements made with narrow beams, while protective barriers generally are exposed to broad cones of radiation. It has been shown previously (1) that the attenuation is less with broad beams because part of the scattered radiation is retained within the confines of the primary beam. It is important, therefore, that the protection requirements be based upon measurements made under conditions actually met in practice. In many instances the lack of dependable data has resulted in inadequate protection against the primary beam and in an excessively high factor of safety for the barriers exposed to scattered rays only.

The purpose of this paper is to report the results of our radiation surveys of nine one-million-volt (1-Mv.) and one two-million-volt (2-Mv.) installations. These findings served in the formulation of the Safety Code for the Industrial Use of X-Rays (2) and are presented here as an aid in the planning of roentgen-ray installations to be used for therapy.

A *maximum permissible weekly dose* of 0.1 r has been assumed. This is the value which will be recommended officially by the Subcommittee on Permissible External Dose, National Committee on Radiation Protection, to replace the present value of 0.1 r per day.

The permissible dose of 0.3 r per week corresponds to 6.25 milliroentgens per hour, or 0.21 milliroentgen per minute, assuming forty-eight hours exposure per week. Actually, the cumulative daily exposure time of most roentgen therapy installations is considerably lower than the daily working hours. Yet, in protection planning it is safer to assume eight hours exposure per day, for it does not increase the cost significantly.

TABLE I: IONIZATION CHAMBERS

Type	Wall Material	Inside Dimensions (cm.) Diameter	Length	Volume (c.c.)	r/Div.*
CX-1 cylindrical	Bakelite	12.05	21.85	2,490	0.23×10^{-3}
SX-11 spherical	Polystyrene	10.5	...	624	0.79×10^{-3}
D-I thimble	Catalin	0.7	2.15	0.783	1.0

* Dose in roentgens per scale division of electrometer.

MEASURING INSTRUMENTS

Radiation protection surveys require the employment of instruments capable of measuring dosage rates of a few milliroentgens per hour. In this study, a preliminary scanning was made at each installation with Geiger counters to determine the locations of maximum radiation. The high sensitivity of the counter apparatus permitted an immediate indication of the approximate radiation level. However, due to the variation in sensitivity of the counter with direction and with radiation quality, this instrument was not used for quantitative measurements. These measurements were made, instead, with large

[1] Presented at the Thirty-third Annual Meeting of the Radiological Society of North America, Boston, Mass., Nov. 30–Dec. 5, 1947.

[2] Physics Laboratory, Department of Hospitals, City of New York.

[3] X-ray Section, National Bureau of Standards, Washington, D. C.

condenser ionization chambers having the characteristics shown in Table I. The center electrode of the chambers was charged to a potential of approximately 300 volts before irradiation, and this voltage as well as that after the exposure was determined by means of a string electrometer. The chambers were calibrated with 175-kv constant-potential filtered roentgen rays and with gamma rays from a known source of radium. Both calibrations checked with the theoretical values calculated from the air volume and capacitance of the chambers. One set of measuring instruments is shown in Figure 1.

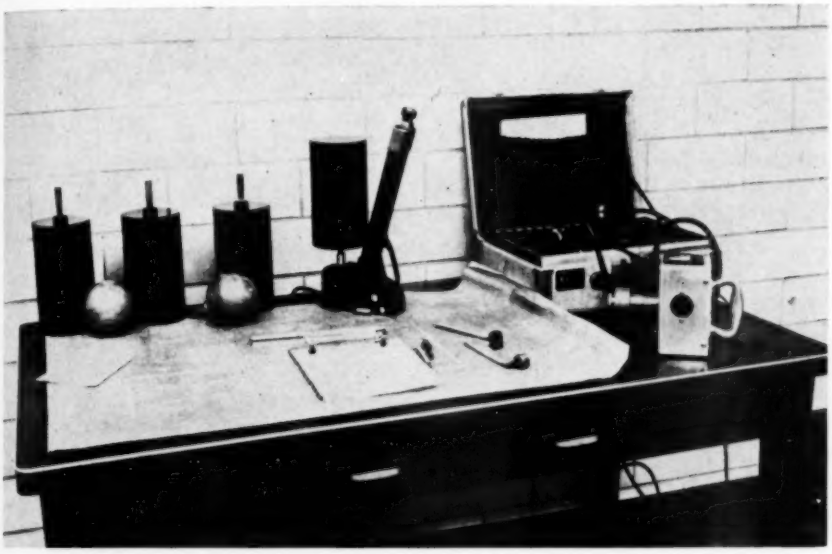

Fig. 1. Photograph of the measuring instruments used.

The chambers were mounted on adjustable stands placed at the strategic locations of each installation, and readings were taken simultaneously at as many as ten positions. Cylindrical lead shields of varying wall thicknesses were placed around the ionization chamber when it was desired to determine the radiation quality.[4]

[4] Such a technic may be shown experimentally to give larger transmission than that obtained by the flat absorber method, by the order of 15 per cent. The error will thus be on the safe side. For the present uses, this accuracy is adequate.

EQUIPMENT

All the surveyed installations used the resonance type high-voltage generator as described by Charlton and Westendorp (3). In this type of equipment the roentgen-ray tube is provided with a target of the transmission type; that is, the axis of the roentgen-ray beam coincides with that of the tube. This construction is used in order to take advantage of the much greater penetrability and intensity of the supervoltage roentgen rays in the direction of the electron beam. Both the hardness and dosage rate decrease as the angle measured from the tube axis in the forward direction is increased.

In Figure 2[5] and Figure 3, for 1 Mv. and 2 Mv., respectively, the polar plots marked *A* show the manner in which the dosage rate at a given distance changes with this angle. The curves marked *B* show the transmission through 1 cm. of lead expressed in per cent of the dosage rate in that direction with no lead filtration. For example, in Figure 3 the percentage trans-

[5] We are indebted to Herbert Mermagen of the University of Rochester for the data on which Figure 2 is based.

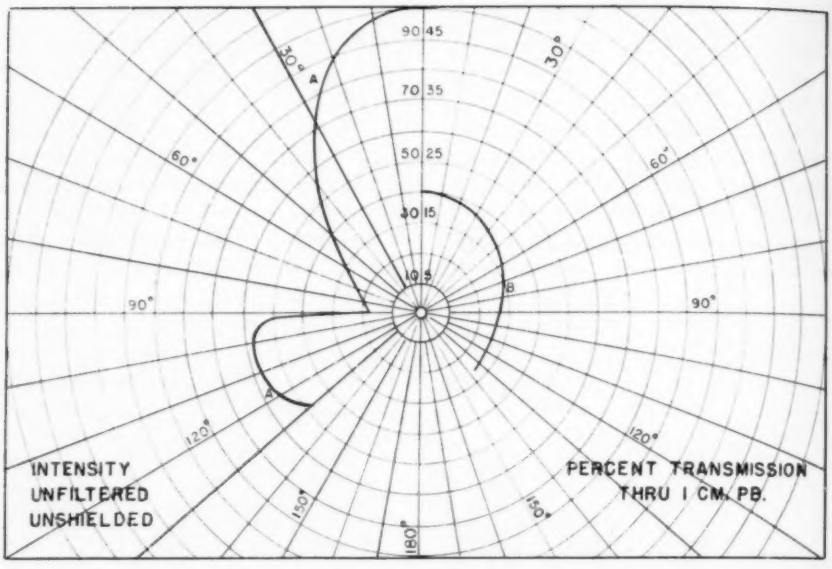

Fig. 2. Angular distribution of dosage and quality for 1-Mv. x-ray generator without protective housing. These distributions have approximately cylindrical symmetry about the 0–180° axis. The projection has been drawn only on one side of one plane through this axis.

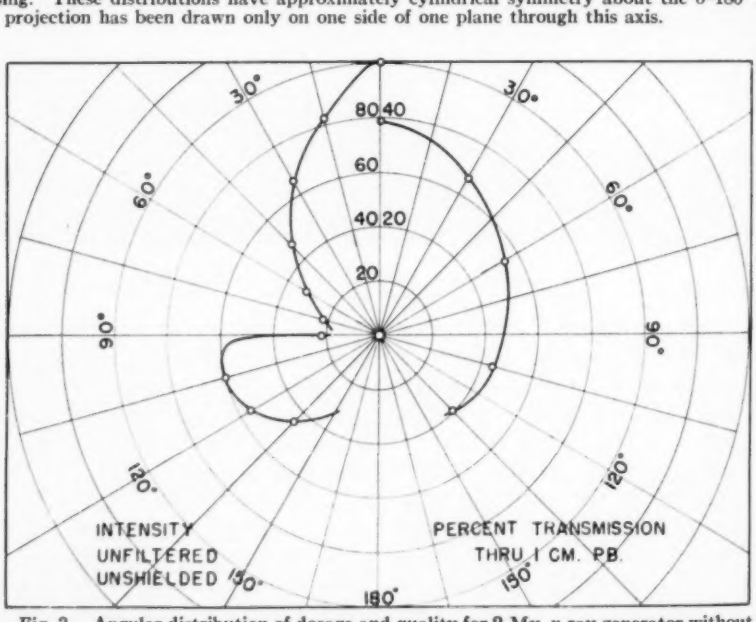

Fig. 3. Angular distribution of dosage and quality for 2-Mv. x-ray generator without protective housing. These distributions have approximately cylindrical symmetry about the 0–180° axis. The projection has been drawn only on one side of one plane through this axis.

mission through 1 cm. of lead for 2-Mv. roentgen rays is, in the forward direction, 40 per cent of what it would be without filter. However, 60° from the tube axis this transmission is approximately 28 per cent. Thus, it may be observed that the radiation in the forward direction is much more penetrating than that off to the side.

This is illustrated more clearly in Figure 4, where the absorption curves for different angles are indicated. The curves were obtained by enclosing the ionization chamber in lead shields of different wall thicknesses. From such curves, it is possible to deduce the attenuations which apply to the radiation in question.

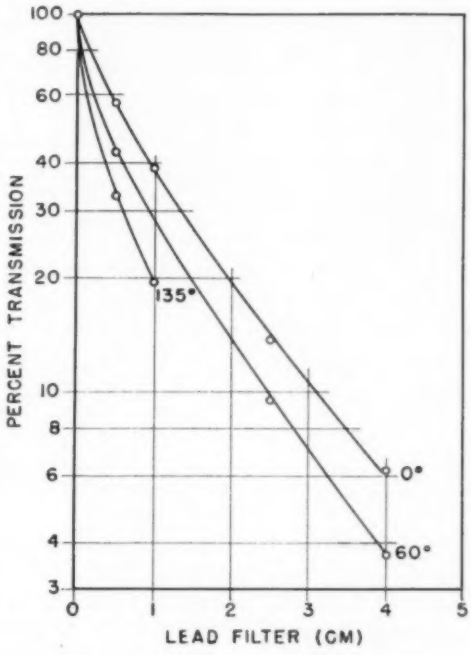

Fig. 4. Absorption curves from a 2-Mv. x-ray generator at different angles without protective housing.

SHIELDING OF ROENTGEN-RAY TUBE HOUSINGS

The structural protection requirements may be reduced considerably by limiting the primary radiation, as far as practical, to the useful beam. This is especially true where the orientation of the x-ray tube is greatly restricted. It is, in any case, essential that the patient be protected against radiation from outside the useful beam. Careful consideration should be given, therefore, to the shielding of the tube enclosure and to the design of the anode cone. The relative dosage rates,[6] with shutter (2 inches thick) closed, obtained from present 1-Mv. equipment in different directions is indicated in Figure 5. The plotted

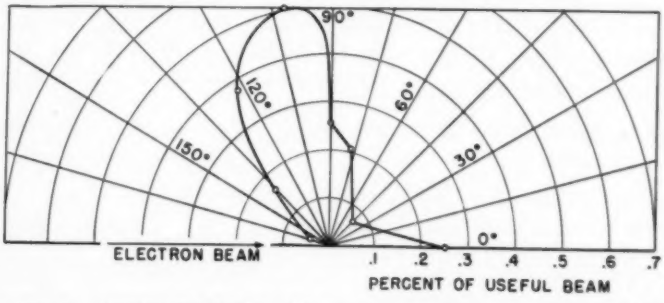

Fig. 5. Angular distribution of dosage about 1-Mv. x-ray generator with protective housing in place. This distribution has approximately cylindrical symmetry about the 0–180° axis. The projection has been drawn only on one side of one plane through this axis.

points were obtained by dividing the dosage rate at a given position by the dosage rate of the useful beam at the same distance from the target. Figure 6 gives the absorption curves at two different angles with the electron beam, measured outside the tube housing. From Figures 5 and 6 it is thus evident that the position near 90° gives the largest leakage and the hardest beam outside of the primary or useful beam. Protection requirements for walls not struck by the primary beam may thus be governed by radiation transmitted in this direction.

The aperture is usually made up of two parts. A fixed portion of the diaphragm system limits the beam to the maximum

[6] We are indebted to Colonel Amory, Captain Wallace, and the Walter Reed Hospital for the use of the apparatus from which Figures 5 and 6 were obtained.

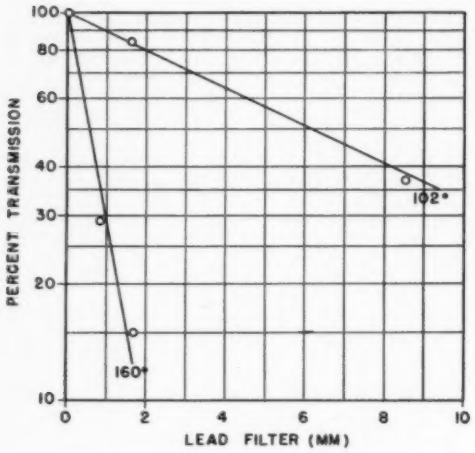

Fig. 6. Absorption curves for different angles from a 1-Mv. generator with protective housing in place.

size of field to be used. An adjustable diaphragm further limits the field size. In order to reduce the weight of the latter to a practical value, the thickness of the adjustable diaphragm is made less than that of the housing protection. A transmission equal to 5 per cent of the useful beam is usually permitted through the auxiliary diaphragm edges. The lead requirements are then approximately 1-¼ inch for 1 Mv. and 2 inches for 2 Mv.

LOCATION OF SUPERVOLTAGE THERAPY ROOM

The cost of protection for 1-Mv. and 2-Mv. installations depends to a large extent upon the occupancy of surrounding areas. The treatment room, therefore, should be located as far as possible from occupied regions in order to take advantage of the inverse-square law. The useful beam most frequently is directed toward the floor. Supervoltage installations, therefore, should preferably be placed on the ground floor with the earth directly below the floor of the treatment room. By using a separate building for the equipment, it is possible further to reduce the protection requirements by eliminating the need for shielding of the ceiling of the roentgen-ray room. Further economy may be attained by restricting the orientation of the beam to the floor and outside walls. However, even outside walls and especially windows may require radiation barriers if close to occupied regions. This is illustrated in Table II, where the distances required to reduce the dosage rate to 6.25 milliroentgens per hour are shown for various conditions.

TABLE II: DISTANCE FROM TUBE TARGET AT WHICH THE DOSAGE RATE OF THE USEFUL BEAM IS 6.25 MILLIROENTGENS PER HOUR*

Tube Current (ma.)	One Million Volts		Two Million Volts	
	Meters	Feet	Meters	Feet
0.25	120	394	232	762
0.5	144	473	277	909
1.0	177	581	325	1,067
1.5	195	640	357	1,171

* This table is based on reduction in dosage rate by both distance and air absorption, but by no other means. In computing the tabular distances it was assumed that the radiation is monochromatic, and that its wave length is double the minimum wave length of the heterogeneous radiation generated by the indicated voltage. The filtration was assumed to be 1.6-mm. tungsten, 5.8-mm. copper, 6.8-mm. water.

All personnel should, in so far as possible, be stationed at a considerable distance from the tube target and in directions which make larger angles than 90° with respect to the electron beam. If this is done, less structural protection will be required, because both the primary and scattered radiation in this direction are less penetrating and of lower intensity than in a more forward direction.

PROTECTION AGAINST PRIMARY RADIATION

At the present time protective barriers for 1- and 2-Mv. roentgen rays may be constructed most economically of concrete. The attenuation of very penetrating radiation in such materials is due, in large part, to scattering. Because of this scattering process, the irradiated portion of the barrier may be thought of as an extended source of degraded radiation. Personnel on the far side of the wall therefore receive radiation not only from the roentgen-ray source—by transmission through the barrier—but also by scattering from the irradiated volume of the barrier itself. The larger the irradiated area and the shorter

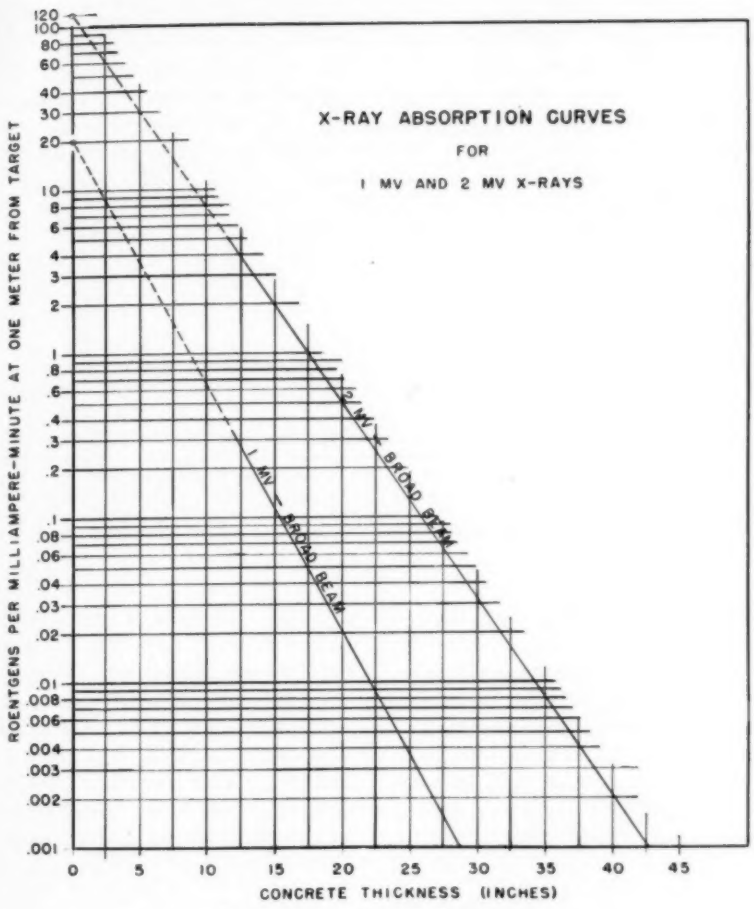

Fig. 7. Concrete absorption curves.

the distance from the barrier to personnel, the greater is the effect. This was recognized in our earlier study (1), where the test conditions simulated the actual conditions met in practice. The attenuation of concrete barriers was determined for broad beams of radiation with the ionization chambers close to the barrier. The absorption curves thus obtained are shown in Figure 7. Table III is computed from these curves. In making these computations, it has been assumed that the permissible weekly dose is 0.3 r and that the cumulative weekly exposure time is forty-eight hours. It was also assumed that the dosage rate per milliampere at one meter is 20 and 120 r per minute for 1- and 2-Mv. roentgen-ray generators, respectively. Air absorption has been neglected. It has been further assumed that the person to be protected will normally be stationed near the protective barrier.

SCATTERED RADIATION

In most supervoltage roentgen-therapy rooms, only the floor and part of the wall area are irradiated by the useful beam. Usually the ceiling and the rest of the walls are exposed to scattered rays only.[7] It is important, therefore, to determine the

[7] In addition to the primary radiation passing through the wall of the tube housing.

TABLE III: THICKNESS OF CONCRETE OF DENSITY 2.35 GRAMS PER CUBIC CENTIMETER REQUIRED FOR PRIMARY PROTECTIVE BARRIERS FOR OPERATION AT THE CURRENT, DISTANCE, AND POTENTIAL INDICATED.*

Target Distance		One-Million Volts								Two-Million Volts							
		0.25 Milli-amperes		0.5 Milli-amperes		1.0 Milli-amperes		1.5 Milli-amperes		0.25 Milli-amperes		0.5 Milli-amperes		1.0 Milli-amperes		1.5 Milli-amperes	
Ft.	Meters	Cm.	In.	Cm.	In.	Cm.	In.	Cm.	In.	Cm.	In.	Cm.	In.	Cm.	In.	Cm.	In.
4	1.22	77.5	30.5	82.6	32.5	87.6	34.5	91.4	36.0	113.0	44.5	119.4	47.0				
5	1.52	74.9	29.5	80.0	31.5	85.1	33.5	87.6	34.5	109.2	43.0	115.6	45.5	121.9	48.0	125.7	49.5
6	1.83	71.1	28.0	76.2	30.0	82.6	32.5	85.1	33.5	106.7	42.0	113.0	44.5	119.4	47.0	123.2	48.5
8	2.44	67.3	26.5	72.4	28.5	77.5	30.5	81.3	32.0	100.3	39.5	106.7	42.0	113.0	44.5	116.8	46.0
10	3.05	63.5	25.0	68.6	27.0	74.9	29.5	77.5	30.5	96.5	38.0	102.9	40.5	109.2	43.0	113.0	44.5
15	4.57	58.4	23.0	63.5	25.0	68.6	27.0	71.1	28.0	88.9	35.0	95.3	37.5	101.6	40.0	105.4	41.5
20	6.10	53.3	21.0	58.4	23.0	63.5	25.0	67.3	26.5	83.8	33.0	90.2	35.5	96.5	38.0	100.3	39.5
30	9.14	47.0	18.5	52.1	20.5	57.2	22.5	61.0	24.0	76.2	30.0	82.6	32.5	88.9	35.0	92.7	36.5
40	12.19	43.2	17.0	48.3	19.0	53.3	21.0	55.9	22.0	71.1	28.0	77.5	30.5	83.8	33.0	87.6	34.5
50	15.24	39.4	15.5	44.4	17.5	49.5	19.5	53.3	21.0	66.0	26.0	72.4	28.5	78.7	31.0	82.6	32.5
75	22.85	34.3	13.5	39.4	15.5	44.4	17.5	47.0	18.5	58.4	23.0	64.8	25.5	71.1	28.0	74.9	29.5
100	30.48	29.2	11.5	34.3	13.5	39.4	15.5	43.2	17.0	53.3	21.0	59.7	23.5	66.0	26.0	69.8	27.5

* These thicknesses are sufficient to reduce the dosage rate of the useful beam to 6.25 milliroentgens per hour under the indicated conditions; they were computed from Figure 7, by using linear extrapolation when necessary and by neglecting air absorption.

EXAMPLE: To find the thickness of a primary protective barrier of concrete required when operating at one million volts, 1.5 ma., at a distance of 8 ft. from the tube target, we find at the intersection of the column headed "1.5 milliamperes" under the main heading "One Million Volts" and of the row corresponding to 8 ft. the value 81.3 cm. or 32 inches. This is the thickness of concrete required for a primary protective barrier in order to reduce the dosage rate of the useful beam to 6.25 milliroentgens per hour under the conditions indicated.

protective requirements of such secondary radiation barriers.[8] The dosage rate and the quality of the scattered radiation, however, vary widely with the size of the field, angle of scattering, and the nature of the scattering material. Furthermore, the intensity of the scattered rays depends also upon the distance from the scattering material and the dosage rate of the incident radiation. With so many variables, it obviously is not possible to obtain protection data which will be universally applicable for scattered radiation. We shall, therefore, limit the discussion to those measurements which are of special significance to the radiologist. In Figure 8 are shown the results of scattered radiation measurements of 1-Mv. therapeutic installation[9] using a fixed tube housing with the useful beam directed down. The phantom was placed in the beam 70 cm. from the target. The dosage rate, measured in air, at this distance was 50 r per minute for 1 Mv. and 3 ma., with a field of 20 × 20 cm. In this arrangement the tube housing protection was so large that no appreciable radiation was transmitted through it. Measurements were made simultaneously at three positions: in the treatment room (*A*), where the ionization chamber was exposed directly to the scattered radiation from the phantom; in the maze (*B* and *C*), where the chambers were exposed to multiple scattered radiation only. On the left are shown the milliroentgen/minute (mr./min.) and absorption curves obtained at the three locations. The absorption curves were obtained by enclosing the ionization chambers with lead shields of varying wall thicknesses. These indicate clearly the great reduction in dosage rate and penetrability as the radiation is scattered more and more. These findings are to be expected according to the theory of the Compton effect.

An approximate calculation may be used to check the reasonableness of these scattering results. The effective absorption coefficient for each of the positions may be obtained from the corresponding absorption curve of Figure 8. The values so obtained are indicated in Table IV. From these absorption coefficients, one may ob-

[8] A secondary radiation barrier is a radiation barrier not exposed to the useful beam.

[9] The authors are indebted to L. Marinelli of Memorial Hospital for making the equipment available for these tests.

tain a comparable effective monochromatic "wave length" by the use of tables given in the literature (4). Position *A* receives radiation by approximately 90° scattering from the useful beam, while position *B* obtains the major portion of its radiation from position *A* by approximately 90° scattering. Compton scattering through 90° should give a wave length

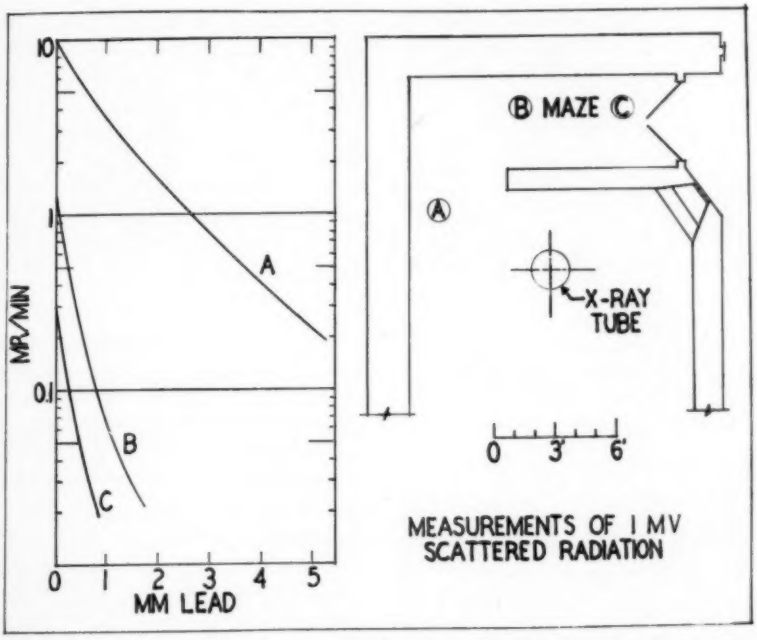

Fig. 8. Scattered radiation measurements. The drawing on the right gives a plan view of the experimental arrangement. The three absorption curves were obtained at the indicated positions.

increase of 0.024 Ångström. The calculated wave lengths are then obtained by adding 0.024 Ångström to the "wave length" of the previous column. Considering the possibilities of error in this crude computation, the agreement between computed and measured "wave length" seems very good. In general, it is possible, therefore, to estimate the quality of the scattered radiation.

As far as the dosage rate is concerned, there is no simple relationship, although we may assume that at 1 meter from the scattering object it is less than 0.1 per cent of the incident beam for 90° scattering. It is of interest to note that the measurements at position *C* indicate that the lead equivalent of the doors could have been reduced to 1/32 inch for the above conditions.

It is obvious, therefore, that barriers exposed to scattered radiation require much less protection than those irradiated by the useful beam. Consequently, it is possible to reduce materially the cost of protection by restricting the orientation of the useful beam to that actually required in treatment and, if possible, directing the beam only toward unoccupied regions.

It should be emphasized here that, while shielding against scattered radiation generally may be less than what is now used in practice, it cannot be eliminated altogether. One frequent cause of inadequate protection is complete lack of shielding against multiple scattered radiation. The radiation may be scattered many times before reaching an occupied area; yet the radiation level is frequently above the permissible 6.25 milliroentgens/hour for forty-eight hours of weekly exposure.

TABLE IV: COMPARISON OF MEASURED AND CALCULATED VALUES

	Useful Beam at 70 cm. Target Distance	Scattered Radiation at Positions		
		A	B	C
Dosage rate	50 r/min.	9.7 mr./min.	1.3 mr./min.	0.28 mr./min.
Per cent of incident beam	100%	0.019%	0.0026%	0.00056%
H.V.L. Pb	5.9 mm.	1.0 mm.	0.4 mm.	0.3 mm.
Absorption coefficient	1.18 cm.$^{-1}$	6.95 cm.$^{-1}$	17.4 cm.$^{-1}$	23.3 cm.$^{-1}$
"Wave length"	0.021 Å.	0.055 Å.	0.082 Å.	0.091 Å.
Calculated "wave length"	....	(0.045 Å.)	(0.079 Å.)	

A comparison of the scattered radiation with the transmitted radiation through the tube housing indicates that the latter is much greater. Moreover, the latter will be much harder and will therefore govern the protection requirements outside of the useful beam. It may be noted from a comparison of Figures 6 and 7 that the addition of an inch of lead around the target end of the tube would decrease the wall requirements by the order of 6 inches of concrete. This latter figure is, of course, only approximate, since Figures 6 and 7 do not deal with radiation of the same hardness.

SUMMARY

Data are presented here for the computation of concrete protection in the primary beam for 1- and 2-Mv. roentgen rays. It is pointed out that considerable saving in weight of concrete can be obtained by using ground-floor or isolated locations for the installation. Information is also presented on the secondary protection requirements. For the present installation, it is necessary to protect against the radiation transmitted through the housing rather than that scattered 90° from the main beam. It is suggested that this housing protection be increased by another factor of 10. The scattered and transmitted intensities would be of the same order. For an estimated 100-pound increase in the tube-housing weight, the wall thickness may be reduced by the order of 6 inches of concrete.

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SUMARIO

Requisitos de Protección en las Instalaciones de Un Millón (1 Mv) y Dos Millones de Voltios (2 Mv) de Rayos X

Ofrécense aquí datos para computar la protección en hormigón que exige el haz primario para 1 y 2 millones de voltios de rayos X. Señálase que puede lograrse un ahorro considerable en el peso del hormigón usando lugares aterrados o aislados para la instalación. También se suministran datos relativos a los requisitos secundarios de protección. Con la instalación actual, resulta necesario protegerse contra la radiación trasmitida por la instalación misma, más bien que por los esparcidos 90° del haz principal. Indícase un aumento en esa protección de la instalación por otro factor de 10. Las radiaciones esparcidas y trasmitidas corresponderían al mismo orden. Calculando un aumento de 100 lbs. (45.36 kg.) en el peso de la instalación del tubo, cabe rebajar el espesor de la pared en 15 cm. de hormigón.

Broad and Narrow Beam Attenuation of 500- to 1,400-Kv. X-Rays in Lead and Concrete[1]

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THERE HAVE BEEN numerous papers over the past ten years dealing with x-ray protection in the range from 500 to 2,000 kv. (1). The data from these papers vary somewhat because the conditions of the experiments were not always the same and could not readily be correlated. Part of this variance has been attributed to differences in the high-voltage wave form and inherent filtration for the various experimental arrangements. Preliminary data (1) have indicated that the size of the irradiated area of the barrier may also be an important variable. The magnitude and limits for this variable have not, however, been explored quantitatively. The present report will deal with x-ray beams of various sizes produced by direct current potentials of 500, 600, 800, 1,000, and 1,400 kv. with a transmission target. Barriers of lead and concrete will be considered. Concrete has been generally accepted in the energy range above about 500 kv. where space is not important, because it is structurally self-supporting and relatively inexpensive. However, for applications requiring a minimum of thickness for a given protection, lead is still the most popular.

In the voltage range under consideration, x-rays are principally absorbed by the photoelectric and the Compton processes, since pair production is still relatively unimportant, even in lead for 1,400 kv. All of the photoelectric absorption and that part of the energy transferred to the Compton electrons are considered to be truly absorbed, since the electrons so produced have small likelihood of producing another x-ray photon. The part of the energy given to the scattered photon leaves the site of the encounter in a different direction from that of the incident photon. The amount of this energy retained by the scattered photon decreases with increase of the angle between the scattered and incident photons. Thus, if the beam is of small cross section, the scattered photons leave the incident bundle and will not be measured. If, however, the beam is of considerable width, the photons scattered from its sides may enter a measuring volume situated near the center of the beam. The apparent attenuation of the beam, measured by the reduction in dosage rate in the barrier, may thus be greatly influenced by the inclusion of this scattered radiation.

One may think of the ionization produced in the ionization chamber placed on the far side of a protective barrier as being due to two different sources of radiation. (*a*) Part of the radiation comes directly from the target of the x-ray tube. (The target is essentially a point source for all practical dimensions used in protective studies.) (*b*) The remainder of the measured dosage may come from a distributed source composed of the entire irradiated volume of the protective barrier. Several factors serve to limit the volume which acts as this secondary source. The length of the incident plus the scattered photon path in the barrier will be greater for oblique rays and, therefore, obliquely incident photons have a greater probability of being absorbed. In addition, the angle between these incident and scattered photons must be larger and, therefore, the scattered photon energy will be smaller. The latter factor, depending upon the atomic number of the protective barrier, may also increase the probability of true absorption. In the x-ray range here considered, this factor is not important for concrete, but serves to

[1] Presented at the Thirty-third Annual Meeting of the Radiological Society of North America, Boston, Mass., Nov. 30–Dec. 5, 1947.

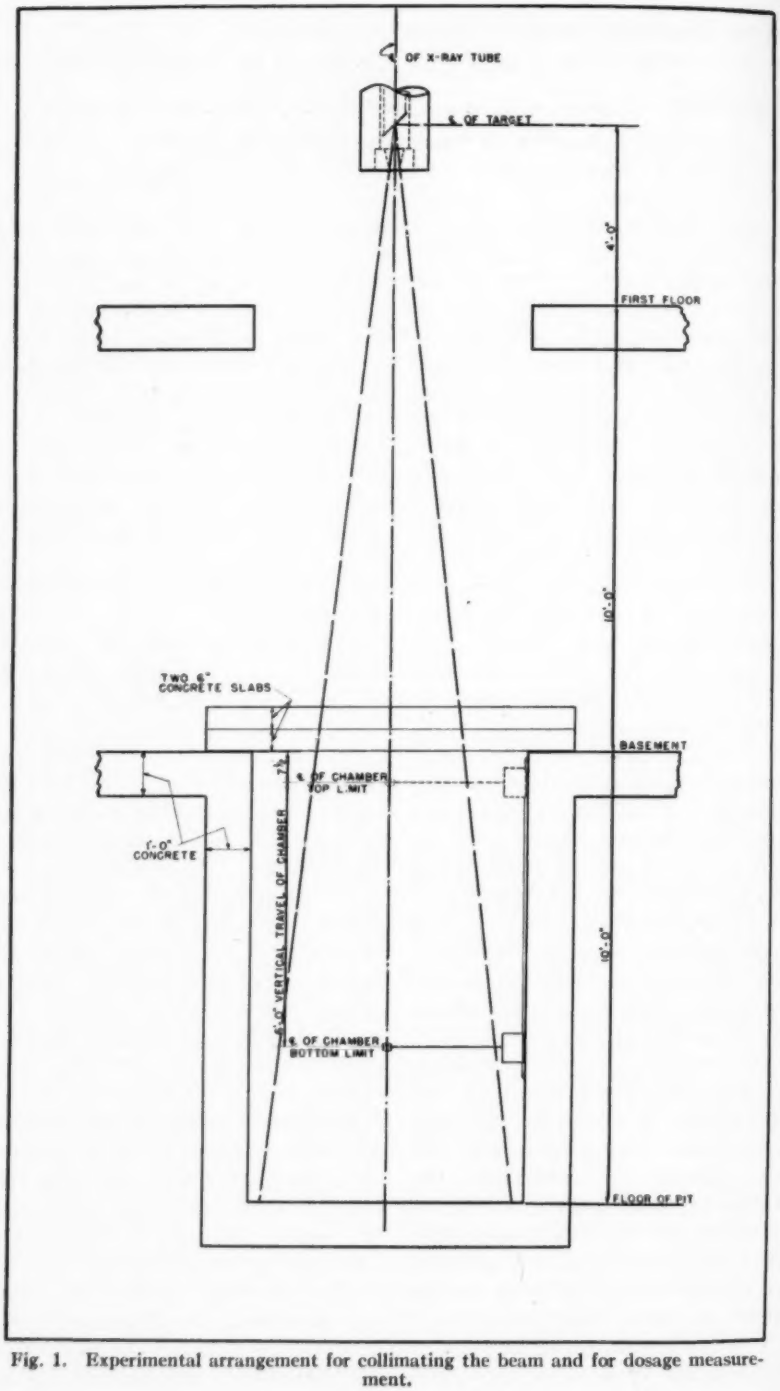

Fig. 1. Experimental arrangement for collimating the beam and for dosage measurement.

limit the practical dimensions of the virtual source when lead barriers are used.

Another factor producing differences between measurements made with and without scattering has recently been described (3). It was shown that air ionization chambers are more sensitive to photons of energies below 70 kev. than above. For increasing thickness of barrier, an equilibrium is soon established so that as much of the low-energy radiation is absorbed as is created. As a result of this quality-dependent chamber sensitivity, one obtains an increase of dosage rate in protective barriers of low atomic number, such as concrete, where this low-energy radiation is not strongly absorbed. The attenuation curves are thus convex upward for small barrier thicknesses. On the other hand, for barriers of high atomic number, such as lead, this effect is not observable, since the low-energy radiations are strongly absorbed in the barrier.

As can be easily seen from the above discussion, different experimental conditions may influence considerably the attenuation curve obtained. Two limiting conditions are thus defined for the work to be reported here. A narrow beam attenuation curve shall be understood to be one where only a negligible amount of the scattered radiation from the barrier is measured in the ionization chamber. Practically, this condition amounts to having the irradiated area on the barrier subtend a small angle at the chamber. This condition may be verified experimentally by an inverse-square check of the radiation received in the chamber. If the inverse-square law is found to hold experimentally, with fixed position of the target and barrier but with variations of the target-to-chamber distance, then the contribution of scattered radiation from the barrier source is negligible.

Dosage readings—with a fixed position of the chamber, target, and barrier—are said to be for broad-beam conditions if, on increasing the irradiated area of the barrier, no increase in dosage rate is observed. This condition is, of course, only unique for that particular barrier-to-chamber distance. The above qualitative considerations indicate that the irradiated area required to fulfill broad-beam conditions will be larger for greater barrier-to-chamber distances. The requisite area may be reduced by shorter target-to-barrier distances and smaller chamber volumes.

Since some scattered radiation is measured by the chamber under broad-beam conditions, but none is measured for narrow-beam conditions, the effective absorption coefficient must be different for the two conditions. The effective absorption coefficient is, however, proportional to the slope of the attenuation curve. Attenuation curves which include different amounts of scattered radiation in their determination should therefore have different slopes.

EXPERIMENTAL ARRANGEMENT

The high-voltage generator and tube have been previously described (2). Figure 1 shows the experimental arrangement for beam collimation and for dosage measurement. The filtration inherent in the x-ray tube was approximately 2.8 mm. tungsten plus 2.8 mm. copper plus 2.1 mm. brass plus 18.7 mm. water for the center of the beam. The target protective housing consisted of a double-walled steel tank filled with lead shot to a thickness of approximately 6 inches, and a solid lead diaphragm 6 inches thick. Three diaphragms of different apertures were used in the course of the experiments. They gave irradiated areas at the basement floor level whose diameters were approximately 13, 26, and 37 inches, respectively. These dimensions were dictated on the lower end by the requirement of uniform irradiation of the chamber and on the upper end by a desire to minimize scattering from the pit walls.

Figure 2 shows a view of the pit in which the radiation measurements were made. The ionization chamber was connected to an evacuated cylinder housing an FP54 electrometer tube and a selection of resistors, and could be moved by remote control both in azimuth and in elevation within the pit. (The chamber actually

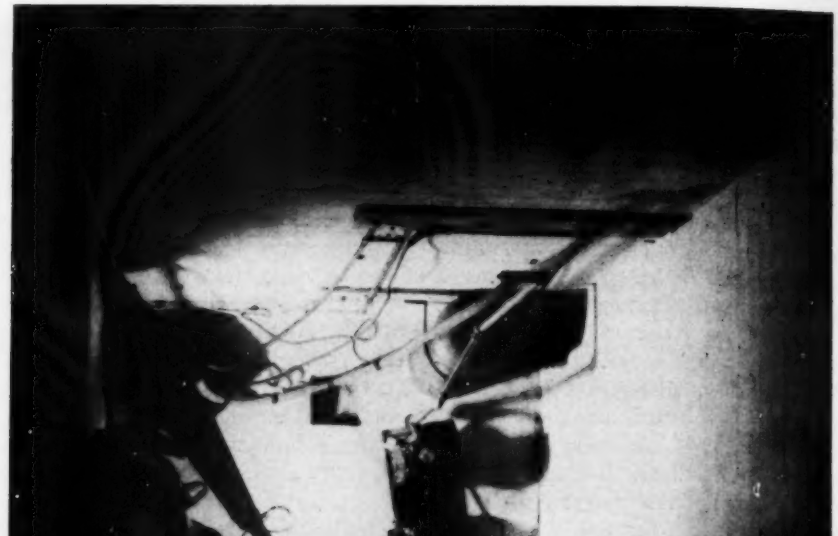

Fig. 2. A view of the pit in which the measurements were made.

used had about 1/25 the volume of the one shown in Figure 2.) Remote switches controlled, and indicators defined, the position of the chamber in the pit, the resistor used, and the grid resistor voltage. The latter two figures together with the volume of the chamber and the temperature and pressure of the air served to determine the dosage rate. The chamber calibration determined from the value of the grid resistor, the grid voltage, and the mass of air in the chamber agrees to within 5 per cent with that obtained experimentally with a standard radium source. By controlling the voltage and the current of the x-ray tube to within 0.1 per cent, the x-ray dosage was found to be constant to 3 per cent. A good share of this fluctuation in output could be attributed to random focal spot motion. It was not considered excessive for the present purposes.

For narrow-beam conditions, the absorbers were placed directly below the shield diaphragm. The chamber-to-absorber distance could thus be varied from approximately 10 to 16 feet. The irradiated area of the samples was not more than 3 inches in diameter.

In testing for broad-beam conditions, the absorbers were laid directly over the top of the pit with an overlap of approximately a foot all around the lip. The con-

crete samples were in one piece, either 8 feet × 8 feet × 6 inches or 8 feet × 8 feet × 3 inches. Lead samples were made up of strips 2 feet × 8 feet, 1/8 inch in thickness. Parallel strips covered the whole surface of the pit aperture in layers 1/8 inch thick. An overlap of at least 1/4 inch was provided at each joint. Lap joints were staggered in adjacent layers but none of the joints came closer than 9 inches to a line through the chamber and target. The lead, being quite flexible, required additional support. The pit aperture was reduced by placing plyboard on the basement floor extending over the pit. An unsupported area of lead 3 feet square was obtained in the center of the aperture. (This area was found to be adequate for broad-beam conditions with concrete. Smaller dimensions were expected and obtained for lead.)

The large concrete blocks were each weighed to an accuracy of 10 pounds. Corrections were made for known air holes and reinforcing iron around the unexposed edges. Thicknesses of each slab, measured at a number of distributed points, were found to deviate by no more than 1/8 inch from their mean value. This mean thickness together with the length, the width, and the corrected weight served to determine the average density. The mean of five additional thickness measurements obtained in the vicinity of the x-ray irradiated area was then corrected to correspond to a specific gravity of 147 pounds per cubic foot (2.35 grams per c.c.). The narrow-beam concrete blocks are those previously used (5). The accuracy of the concrete dimension measurements is estimated to be within 2 per cent.

Approximately 300 measurements of thickness of the lead strips indicated maximum deviation from the mean of the order of ±4 per cent.

All attenuation curves were obtained for a chamber-to-barrier distance of 7½ inches. This distance was a practical lower limit for our equipment. However, personnel are usually not located closer than 7½ inches to the protective barrier in most medical x-ray installations. The target-to-chamber distance was thus 175 1/2 inches.

RESULTS

In order properly to evaluate this experiment, it was first necessary to investigate the extraneous scattering. Evidence of the lack of scattering without absorber may be obtained by observing the dosage rate at different distances from the target. The inverse-square law may be used to reduce these dosage rates to a common distance. The variation of the values, so computed, is a measure of the amount of scattering present. Figure 7 (A) indicates the magnitude of the scattering. It is seen that, with no absorber in place and for the two smaller diaphragms, dosage rates computed back to a fixed distance (1 meter) by the inverse-square law remain essentially constant for large variations of the target-to-chamber distance. With the largest diaphragm, the main beam actually begins to strike the side walls about half way down the pit. The resultant scattering from the walls may contribute to the dosage rate measured in the center of the beam. Since the scattering is most important in the forward direction, some increase in the measured radiation should be obtained for chamber positions below the mid-depth of the pit. The experimental evidence verifies this qualitative prediction. Figure 7 (A) indicates that the contribution of scattering is about 5 per cent of the main beam at a distance of 80 inches below the lip of the pit.

Scattered radiation will, of course, be measured with an absorber over the pit. The lack of extraneous scattering from the pit walls may be determined by measuring the radiation very near to the wall. If the radiation measured near to the wall is a small part of that in the center of the beam, then any contribution received at the center of the beam from the wall may be negligible. In Figure 3 the pit walls correspond to angles of approximately −5° and 95°. The experimental results indicate that the dosage rate is rapidly decreasing

as the walls are approached. The amount of radiation scattered from the nearer wall to the center of the beam is thus negligible. The dosage rate measured at the center of the beam and 7½ inches from the absorber therefore does not include an appreciable amount of scattered radiation.

Figure 3 is of interest also in other respects. The sloped central portion of the azimuth curve without absorber has been discussed previously in the literature (4). It may be attributed to change of the inherent filtration with angle. The asymmetry results from having the target set at 45 degrees to the emergent beam. Large azimuth angles on this figure correspond to least inherent filtration. The figure also indicates that the presence of an absorber tends to sharpen the main peak and to increase the dosage rate near the foot of the curves. The first factor may be attributed to diminution of the beam by larger thicknesses of material at angles different from the normal to the absorber; the second factor, to the radiation scattered out of the confines of the original beam.

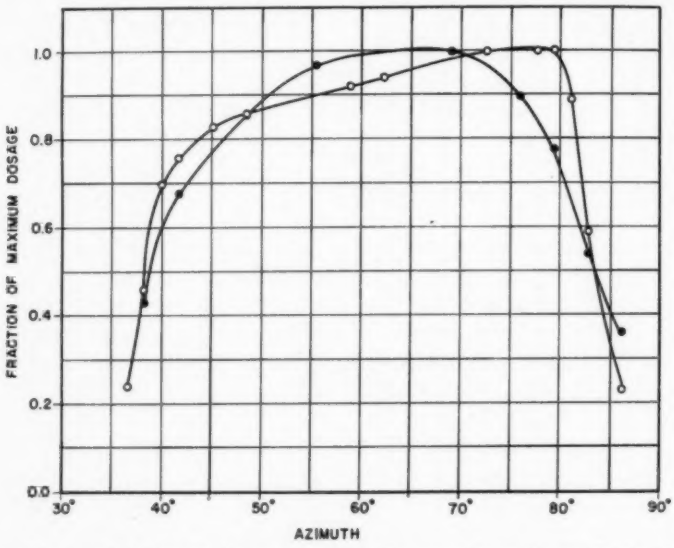

Fig. 3. Variation of dosage rate across the x-ray beam for an irradiated area approximately 37 inches in diameter. The open circles indicate results obtained with no barrier; the filled circles, with a 6-inch thick concrete absorber in place.

It was found that each diaphragm gave a different apparent tube output. This increase in dosage rate with diaphragm size was attributed to spread of the focal spot. In order to show more clearly the effect of beam size on the attenuation curves, all dosage rates for a given diaphragm and kilovoltage have been reduced by the ratio of the apparent tube outputs—with zero absorber—for that diaphragm and for the smallest diaphragm. All four sets of curves for a given voltage thus pass through the same zero absorber point.

Figure 4 shows the experimental attenuation curves for lead. The lower curve at each potential is for narrow-beam conditions. There was no important change in the data for irradiated areas greater than 13 inches in diameter. The actual deviation of the dosage rate for variation of the diaphragm was of the same order as the experimental error. There is, however, an interesting change in the difference between narrow- and broad-beam absorption curves with potential producing the x-rays. In agreement with the qualitative predictions, this difference becomes more important for large photon energies, since

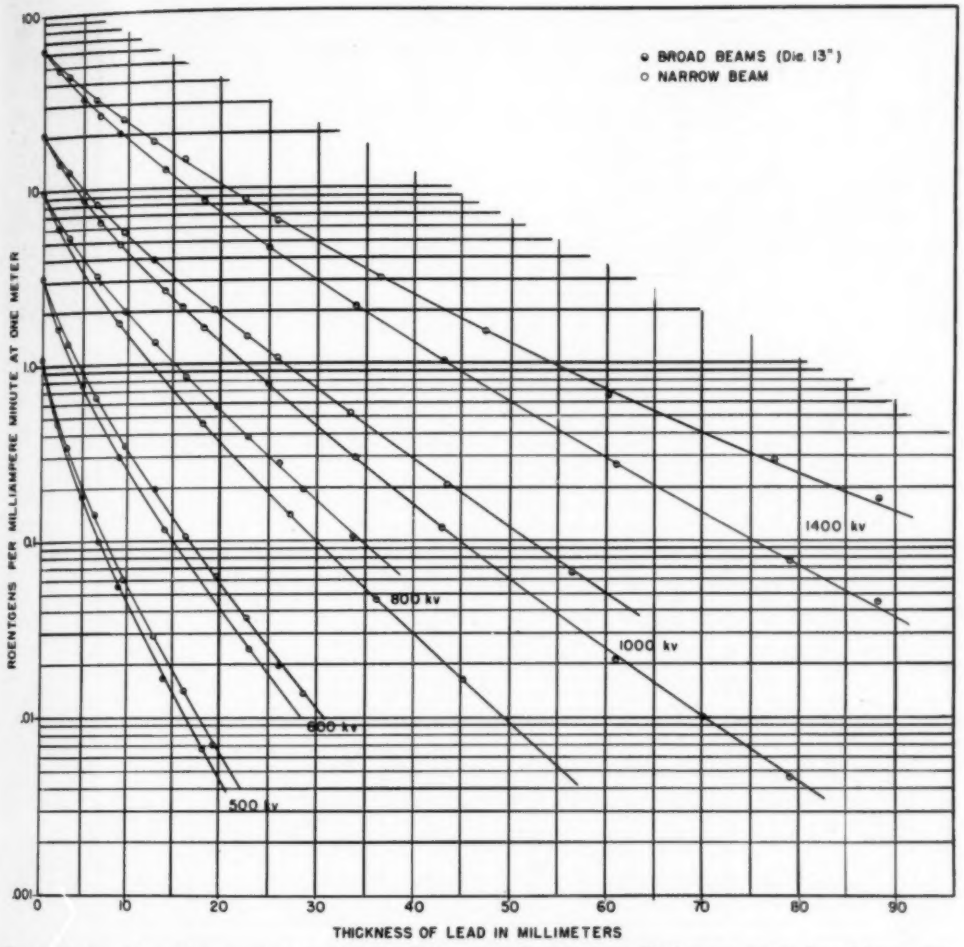

Fig. 4. X-ray attenuation curves in lead. The dosage rates for the three diaphragms under broad-beam conditions were so nearly the same that they could not be separated on this scale.

the scattered photons are not so readily absorbed photoelectrically.

Figures 5 and 6 show the attenuation curves for concrete. For each generator potential, the lowest curve is for narrow beam conditions, that is, when a negligible amount of the dosage is due to scattering from the absorber. The difference between successive curves with narrow beam, 13, 26, and 37 inches irradiated diameter, indicates the magnitude of the scattering from the corresponding ring of barrier. It is evident that the scattered photons from the successive outer rings contribute less and less to the dosage rate measured on the axis of the beam. Because of the small change in dosage rate between the 26-inch and 37-inch beam, and because of the rapidly decreasing contribution of scattering with beam size, the 37-inch diameter beam in concrete has been assumed for all practical purposes to correspond to broad-beam conditions under the experimental arrangement described above.

For comparison with data obtained from a resonance x-ray generator, two experimental points from Singer, Braestrup, and Wyckoff (SBW) (1) have been included on Figure 5. These were obtained with a two-million-volt resonance type unit operating

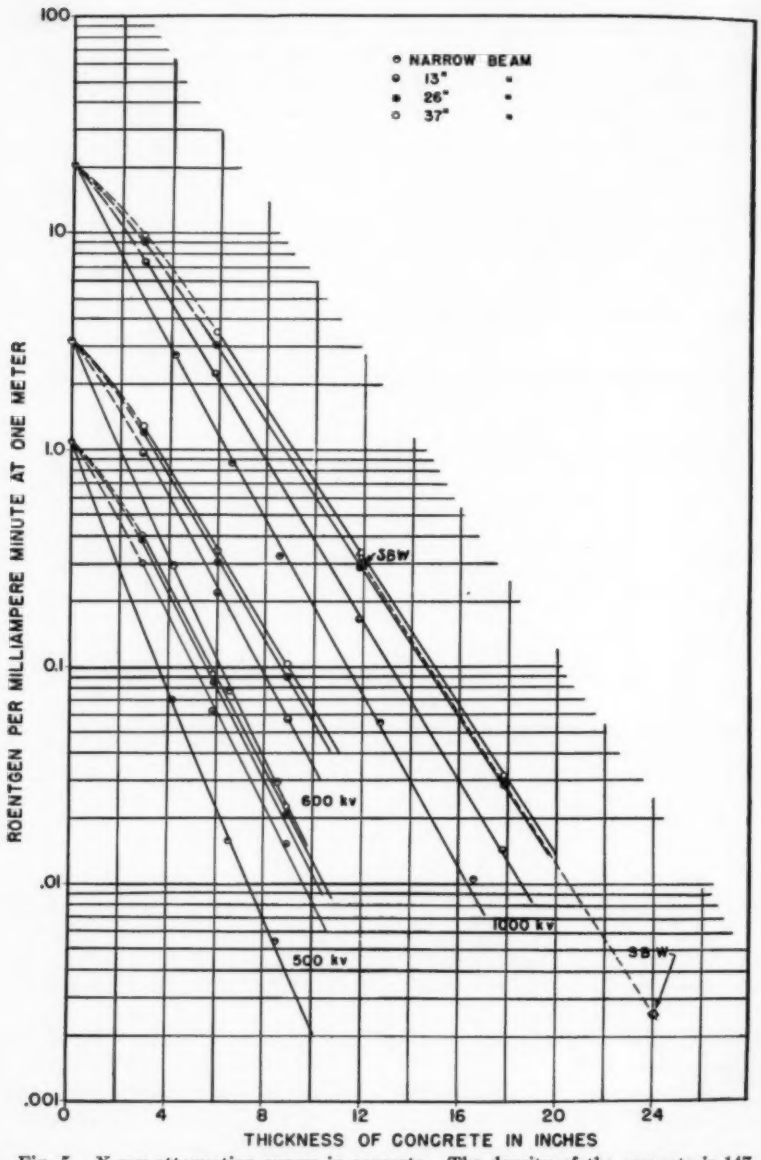

Fig. 5. X-ray attenuation curves in concrete. The density of the concrete is 147 pounds per cubic foot. The dotted line is drawn through two experimental points obtained from published work of Singer, Braestrup, and Wyckoff with a resonance type generator.

at one million volts and giving an irradiated area of approximately 4 1/2 feet by 7 feet. The target-to-chamber distance was approximately 8 and 9 feet. These data have been corrected as nearly as possible to the experimental conditions used for our new data. The effect of the wave form on the x-ray output and the effect of the shorter target-barrier distance on the amount of the scattering measured in protection studies cannot be determined quantitatively with our present knowledge. One may say, however, that the target current flows appreciably only when the

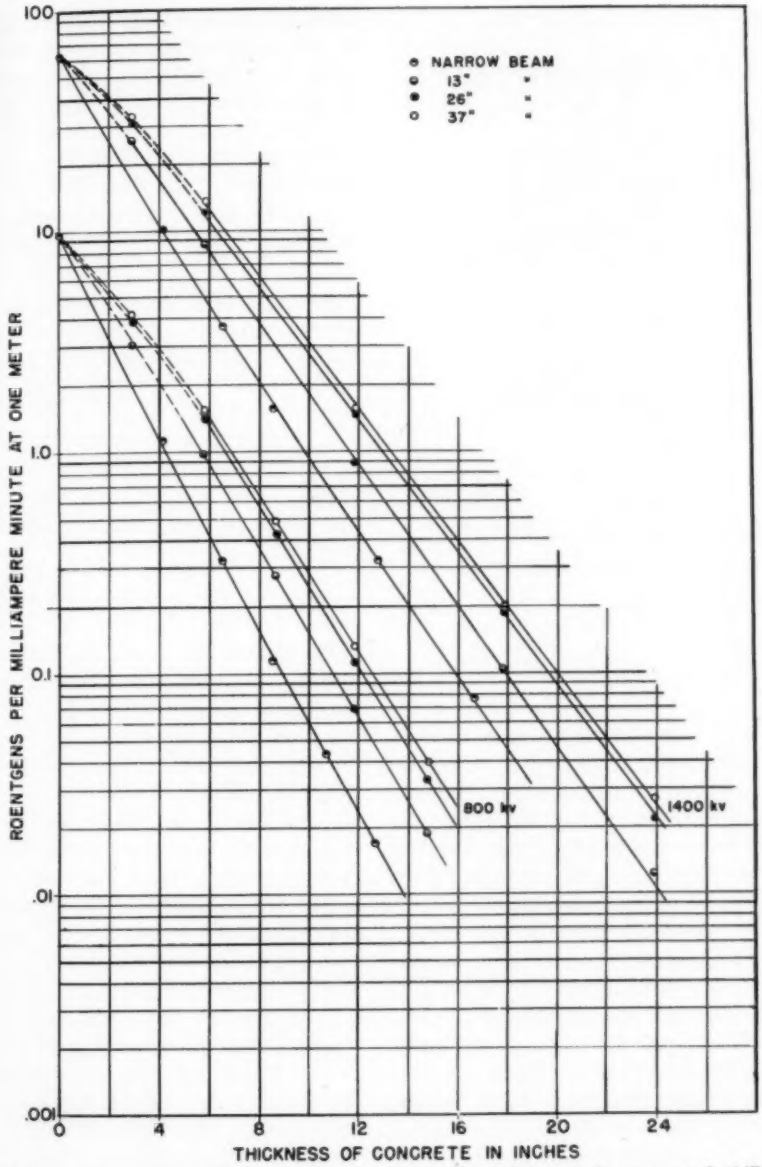

Fig. 6. X-ray attenuation curves in concrete. The density of the concrete is 147 pounds per cubic foot.

alternating voltage peak is above 800 kv. The effective potential should therefore be somewhere between 800 and 1,000 kv. The slope of an attenuation curve is often taken as a measure of the effective potential of the x-rays. The points from Singer, Braestrup, and Wyckoff give a line whose slope is midway between that here reported for 800 and 1,000 kv. The results are thus in qualitative agreement.

There is evidence, in the lead as well as the concrete curves, of a reduction in the slope of the attenuation curve with irradiated area. This effect is especially

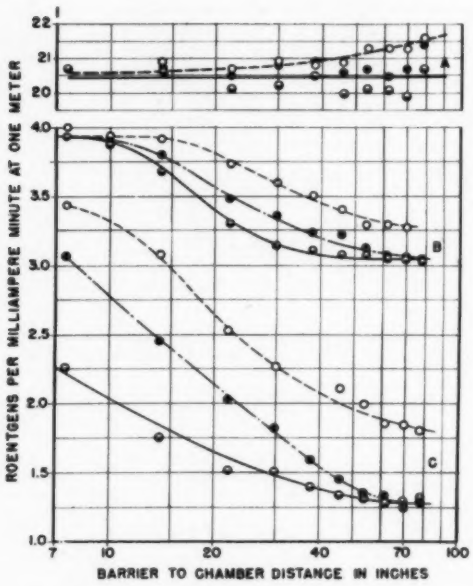

Fig. 7. Samples of the variation of x-ray dosage with distance from the lip of the pit for 1,000 kv. A. With no absorber in the beam. B. With 12.9 mm. of lead over the pit. C. With 5.8 inches of concrete over the pit.

pronounced in the change from narrow beam to 13-inch diameter beam. There is also evidence in concrete, but not in lead, of the low-energy scattered radiation. Both of these items tend to increase the barrier thickness requirements for broad beam over those for narrow beam.

Figure 7, for data taken at 1,000 kv., shows the importance of barrier-to-chamber distances. These curves were obtained by varying the elevation of the chamber in the pit; B is for a lead absorber placed over the pit. The three diaphragms give essentially the same dosage rate at a distance of 7½ inches below the absorber. Broad-beam conditions were therefore obtained at this position for an irradiated area of 13 inches in diameter. As the barrier-to-chamber distance is increased, different diaphragms do not give the same dosage. Broad-beam conditions, therefore, do not exist in this intermediate region for the diaphragms used. At very great distances the dosage rates appear to become constant. This condition corresponds to the requirements for narrow beam. As would be expected, the distance from the barrier for narrow-beam conditions increases with the size of the irradiated area. After correction for scattering, the dosage rate of the largest beam also agrees with that of the other beams at a distance of 78 inches. Moreover, this constant dosage rate agrees with that obtained for the narrow beam curves of Figure 4. For the concrete sample indicated (Fig. 7, C), it appears that the two smaller diaphragms approach narrow-beam conditions for a chamber-to-barrier distance of the order of 55 to 78 inches. The dosage rate is here constant (1.3) and in agreement with the narrow-beam curve of Figure 5, which also gives a value of 1.3 roentgens per milliampere minute at one meter.

CONCLUSIONS

Because of the small irradiated areas required for broad-beam conditions in lead, the broad-beam attenuation curves should be used for nearly all cases where lead barriers are considered in the voltage range reported here. The extra thickness of lead required for broad-beam conditions over that for narrow beam varies rapidly with x-ray tube potential. This extra thickness requirement varies from approximately 10 per cent at 500 kv. to 25 per cent at 1,400 kv.

For concrete protective barriers the difference between narrow and broad beam thickness requirements is of the order of 1½ to 2 half-value layers depending upon the portion and kilovoltage of the curves considered. If the irradiated area of the barrier is not more than 3 feet in diameter and if all personnel are restricted to distances greater than 10 feet from the barrier, then narrow beam attenuation curves may be used in designing x-ray protection. Such restrictions are not usually feasible, however, because of space limitations. In addition, the cost of acquiring the extra space may exceed the saving in barrier cost.

For the majority of x-ray installation designs, therefore, the broad-beam attenuation curves should be used.

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SUMARIO

Atenuación en Plomo y Hormigón de los Haces Anchos y Estrechos de Rayos X de 500 a 1,400 Kv.

Se han obtenido curvas de atenuación de los haces tanto estrechos como anchos para los rayos X de 500, 600, 800 y 1,000 kv. en plomo y hormigón. En las condiciones utilizadas en el experimento, se demostró que un área irradiada de 30 cm. de diámetro con el absorbente de plomo y de 92.5 de diámetro con hormigón cumplía las condiciones necesarias para la atenuación de los haces anchos.

Debido a las pequeñas áreas de irradiación que requiere la atenuación de haces anchos en plomo, deben usarse las curvas de atenuación de haces anchos para casi todos los casos en que se consideran vallas de plomo correspondientes a esa escala de voltaje. El mayor espesor de plomo exigido para los haces anchos, comparados con los estrechos, varía rápidamente con el potencial del tubo de rayos X: de aproximadamente 10 por ciento a 500 kv. a 25 por ciento a 1,400 kv.

Para las vallas protectoras de hormióng la diferencia del espesor entre los haces estrechos y anchos corresponde a $1^1/_2$ a 2 capas de hemirreducción conforme a la porción y kilovoltaje de las curvas consideradas. Si el área irradiada de la valla no excede de 90 cm. de diámetro y se retiene todo el personal a más de 3 metros de distancia de la valla, en ese caso pueden usarse curvas de atenuación de rayos estrechos al planear la protección contra los rayos X. Sin embargo, esas condiciones no suelen resultar factibles debido a las limitaciones impuestas por el espacio disponible.

Por consiguiente, hay que usar curvas de atenuación de haces anchos al proyectar la mayoría de las instalaciones de rayos X.

Thrombocytopenic Purpura Following Therapeutic Administration of Radioactive Sodium

A Case Report[1]

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HEMATOLOGIC complications in the form of leukopenia, anemia, and thrombocytopenia are known to follow the therapeutic administration of radioactive materials due to their profound effect upon the bone marrow (3). In some cases, these occur weeks after therapy has been discontinued. When more than one of the changes occur in the same individual, the white blood cells usually decrease first, the platelets second, and the red cells last. A severe and even fatal aplastic anemia may result.

A striking complication is thrombocytopenia, since it may develop without any change in the other elements of the blood and announce itself by some clinical manifestation of bleeding. This may take the form of petechiae, ecchymosis, bleeding from the gums, epistaxis, retinal hemorrhage, melena, hematuria, or hematemesis. It should be determined that the fall in platelets is not a manifestation of the dyscrasia which is being treated, for this may often accompany leukemia.

Thrombocytopenia may be a transitory and clinically insignificant complication, or it may go on to a condition of serious consequence. Bleeding associated with thrombocytopenia may not be a primary cause of death, but the bleeding may be persistent and profuse and in this way contribute to a fatal outcome. As with other therapeutic measures, a considerable variation in susceptibility of different patients to the toxic effects of radioactive isotopes has been found. Complications sometimes follow comparatively small amounts of the material while much larger quantities are tolerated by other patients without difficulty.

The hard gamma rays of radioactive sodium (Na^{24}) provide a general radiation effect, whereas its beta radiation gives a more localized treatment of organs containing large amounts of blood and body fluid (2). Thus radiosodium is similar in its action to "spray" roentgen therapy, producing a rather uniform irradiation of the whole body. Radiosodium has been shown to be slightly more concentrated in vertebrae, liver and kidney than in muscle or intestine. The amount excreted is less than 10 per cent of the administered dose and is quite constant. The radiation dose delivered by a millicurie of radiosodium (Na^{24}) is about one-fifteenth that of a similar amount of radiophosphorus (P^{32}), and its effect is less protracted.

The radiosodium (Na^{24}) which we use is obtained from the Cyclotron Laboratory of the Physics Department of Columbia University. It is delivered as an approximately isotonic solution of sodium chloride, and has a half-life of 14.8 hours. The usual dosage is from 15 to 30 millicuries, which will provide approximately 20 to 40 r of total body irradiation, and is measured just before administration by the Department of Radiological Research in the College of Physicians and Surgeons. The material is given by mouth in two or three lots, ten to fifteen minutes apart, followed by an equal volume of water for rinsing the mouth and upper alimentary tract.

The following case report is in no way intended to discourage the use of radioactive substances, but illustrates an un-

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[1] From the Radiological Service of the Presbyterian Hospital and the Department of Radiology of the College of Physicians and Surgeons of Columbia University. Presented at the Thirty-third Annual Meeting of the Radiological Society of North America, Boston, Mass., Nov. 30–Dec. 5, 1947.

usual complication which may not be prevented, even by frequent blood studies.

CASE REPORT

A husky, 21-year-old Army officer, weighing 175 pounds, first noticed a painless swelling, about 9 × 5 cm., over his right lower ribs just lateral to the nipple, in March 1945. Pain began one month prior to admission, and at operation, in September 1946, 15 cm. of the 6th rib were removed with the tumor, which was invading the surrounding soft tissues. Histologically, it proved to be metastatic sympathicoblastoma, and postoperative x-ray treatment was given to the operative site and adjacent chest wall. Six months later, the patient returned with generalized osseous metastases and diplopia associated with destruction of the base of the skull. The diplopia and pain accompanying the metastases disappeared after small exposures of local roentgen therapy.

Because of the nature of the metastases and their radiosensitivity, radiosodium was started at the next recurrence of pain. Before each ingestion a complete blood count, including the platelets, was made. After six doses, totalling 110.5 millicuries in seventeen days, all pain disappeared and the patient remained free of pain for four months. After most of these treatments, he experienced slight radiation sickness and, on two occasions when he did not, he noticed a slight soreness in his mouth. Moderate doses of 15 to 30 millicuries were given at about monthly intervals, and always relieved the symptoms within two or three days. Twice a slight leukopenia and lymphopenia developed, but disappeared within a few days. The erythrocyte counts, hemoglobin concentrations, and platelet numbers were never low until the last episode.

Ten treatments in all were given, totalling 202 millicuries, or 285 r, over a period of five months. Within one week after the last treatment, a sore mouth and bilateral retinal hemorrhages developed, with hemorrhages in the mucous membranes of the tongue and gums and in the skin. The platelets rapidly fell from 170,000 to 30,000 in one week, although all the other elements were normal, including capillary fragility and prothrombin time. The bleeding time was six minutes; coagulation time five minutes; but the erythrocyte sedimentation rate was elevated to 110 millimeters in one hour. The serum phosphatase was 1.7 Bodansky units per 100 c.c. of blood, which is within normal limits. Profuse bleeding from the kidneys and intestinal tract occurred, and the platelet count fell to 1,000. Eleven transfusions of 500 c.c. of fresh, whole blood were given, but the patient continued to lose blood steadily from all the mucous membranes, and platelets could hardly be found in the peripheral blood. The final state was one of aplastic anemia.

Autopsy, in November 1947, confirmed the clinical findings and showed that the primary tumor arose from the region of the right cervical sympathetic nerves. The bone marrow was pale and microscopically showed erythroid hyperplasia and myeloid hypoplasia with occasional clumps of tumor cells. The most extensive metastases were in the skull and meninges; the adrenal glands were normal. Punctate hemorrhages were found everywhere; clotted blood was encountered in the pelvis of the left kidney, and hemosiderosis was present in the spleen and bone marrow.

DISCUSSION

After careful study, the opinion of a hematologist was that the purpura in this case was initiated by radiosodium, and was not caused by the malignant disease itself, although the bone marrow could have been exhausted by a combination of the neoplasm and the radioactive toxic effects. Other patients received as much or more radiosodium without similar reaction, but this young man seemed to become more susceptible to succeeding treatments.

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(For Spanish Summary, see following page)

SUMARIO

Púrpura Trombocitopénica Consecutiva a la Administración Terapéutica de Sodio Radioactivo. Historia Clínica.

Preséntase un caso de púrpura trombocitopénica consecutiva a la administración terapéutica de sodio radioactivo en un caso de simpaticoblastoma metastático. Durante un período de cinco meses se administró un total de 202 milicuries de radiosodio (=285 r). El dolor se alivió y repetidas hematimetrías no revelarón anomalías hasta después del último tratamiento, cuando aparecieron manifestaciones hemorrágicas y la numeración de plaquetas descendió rápidamente, aunque todos los demás elementos continuaron siendo normales. La muerte se debió a anemia aplástica, y la autopsia reveló hemorragias punteadas por todas partes, sangre coagulada en la pelvis de un riñón y hemosiderosis en el bazo y la médula ósea.

En este caso, la púrpura pareció deberse al sodio radioactivo y no a la neoplasia misma, aunque la médula ósea pudo haber sido agotada por la combinación del tumor y los efectos tóxicos del radiosodio. Se han observado variaciones en la susceptibilidad a esta sustancia. Otros enfermos recibieron dosis iguales o mayores que las administradas en el caso comunicado sin reacciones semejantes.

DISCUSSION

(Papers by Braestrup and Wyckoff; Wyckoff, Kennedy, and Bradford; Jacox)

John G. Trump, Sc.D. (Cambridge, Mass.): We are indebted to Dr. Braestrup and to Dr. Wyckoff for their authoritative and consistent data on the attenuation of direct and scattered radiation from supervoltage x-ray sources in the 1,000,000-, the 1,400,000-, and the 2,000,000-volt range. It is this supervoltage region which is probably destined to take the next significant place in the history of radiation therapy. Roentgen rays produced by one, two, and a few million volts lie the nearest to the roentgen-ray range which has been exploited by radiologists in the past. They are characterized by unusual high skin tolerance, by higher penetration, which permits more effective irradiation of the deep tumor, by much reduced scattering, and by a sufficiently low exit dose. Such radiation has the enhanced possibility of efficient irradiation of a deep tumorous region with relatively little irradiation of surrounding healthy tissue.

We gather that the absorption of the direct and scattered supervoltage radiation can be accomplished by ordinary construction materials and by the use of normal construction principles. Concrete remains the most practical and economic absorber, perhaps re-enforced with iron or with barium where space considerations are of importance. Lead still remains the most space-economical absorber for the supervoltage region, about 6 inches of lead being equivalent approximately to 36 inches of concrete for 2,000,000-volt radiation.

It will be of interest to have the data presented by Dr. Braestrup for pulsating equipment extended to constant-potential equipment, since this constant-potential radiation value exhibits a higher penetrability and is generally more desirable as a reference standard for protection and other measurements. The absorption of supervoltage radiation is accomplished, as was stated by both essayists, primarily by the Compton mechanism and is therefore largely independent of the atomic number of the material, depending almost solely upon the weight of the interposed material.

While we are interested in supervoltage radiation, it is interesting to remember that a protection problem still exists with the lower-energy radiation, the direct and scattered radiation produced by fluoroscopic and diagnostic equipment. Both Dr. Braestrup and Dr. Taylor have repeatedly in the past suggested the hazards attendant upon normal low-voltage radiation. Errors in diagnostic procedure and the residual scattered radiation from equipment itself or the patient often bring the daily dose beyond the assumed safe value of 0.1 r per day. Nor is it altogether clear that 0.1 r per day is actually the safe value both from the immediate and long-range points of view. It probably would be useful if the workers in the field of radiation were to carry an ionization chamber or some equivalent dosage-recording instrument and maintain a log of the radiation which they accumulate, for we are indeed entering an era in which high-energy radiation will become increasingly prevalent, and it is important that we be aware of the accumulated doses to which we are subjected.

Edith H. Quimby, Sc.D. (New York): Dr. Trump has sufficiently and ably discussed the two papers on protection; there is nothing further for me to say about them.

With regard to Dr. Jacox's patient, I do want to emphasize the point that he brought out, that this is *one* case. A large number of patients have been treated with radioactive sodium at the Columbia Medical Center; however, this was the only one that was treated for this particular condition. Whether that was coincidence or not I do not know, but I do not believe that any such finding in a single patient should discourage the use of this substance under carefully controlled conditions.

W. Edward Chamberlain, M.D. (Philadelphia, Penna.): I would like to ask a question of Dr. Jacox, and perhaps Dr. Quimby. Is it faulty thinking on my part to be more interested in radioactive phosphorus than in radioactive sodium for the type of case that Dr. Jacox presented? It has seemed to me that by its very nature radioactive sodium is a good deal like total body irradiation, to which Dr. Jacox compared it, and that what we want is something which permits of just a little more concentration or a little more favorable distribution. I say that, well knowing from sad and personal experience that radioactive phosphorus has a way of concentrating itself in some places where we would prefer that it did not do so, as, for instance, in the bone marrow. At the same time, I have had the rather remarkable experience of seeing one most surprising case (which, of course, means nothing), a highly anaplastic, metastatic carcinoma in which a favorable effect was obtained with radioactive phosphorus. I would like to do more of this work and I am anxious to know whether I am right or wrong in thinking that radioactive phosphorus may have more promise than radioactive sodium.

Lauriston S. Taylor (National Bureau of Standards, Washington, D. C.): There was a point raised in Dr. Braestrup's paper to which I would like to add emphasis. He pointed out that where the degrees of flexibility of an x-ray tube were somewhat restricted, the problem of radiation protection could be simplified. I am sure we are all conscious of the severe economic problem involved in x-ray protection. In the ordinary diagnostic range, protection may represent 10 per cent of the total cost of an installation; at 200 kv. it may amount to 15 per cent; at 400 kv. to 40 per cent. By the time we get up to a million volts it may amount to almost 100 per cent; in other words, you will have to spend almost as much on protection as you do on your basic equipment.

There are very definite ways for cutting down on these costs, and one of the simplest that I can think of consists in limiting the angulation of the x-ray tube. If, for example, you have a million-volt x-ray tube which can be utilized satisfactorily from the horizontal down to the vertical in direction, and perhaps with some up-and-down motion, then you need to provide primary protection only for that radiation in the directions in which the main beam can strike; the secondary protection, off to the side and in the rear, can be relatively very much simplified.

An example of that came up in our laboratory a few days ago, applying to the 400,000-volt region. We had a case brought to us by a hospital planning essentially a rectangular x-ray room. Off in one corner was a 400-kv. tube arranged to be raised and lowered slightly and such that the beam could be taken outside in any direction from the horizontal to the vertical. The outside wall in this case was the only wall that would require little or no protection; all the rest of the space—behind, beside, above, and below—required protection. When we analyzed this situation, we found that moderately heavy protection would be required on the floor for the direct x-ray beam; however, a startlingly small amount of protection was required for the back wall, the side walls, and the ceiling, because the only radiation against which they were protecting was the scattered radiation from 400 kv. We went through the problem for these people and then, as an afterthought, they said: "Oh, yes, we have a 200-kv. tube in the same room." This 200-kv. tube was on a mobile mount, could be squirted in any possible direction, could be moved to any place or any position in the room. Then we started out to figure what the 200-kv. protection requirements were and found that they were practically double those for the 400-kv. In other words, for this very flexible x-ray tube of 200-kv. variety, we required twice as much protection as for the 400-kv. tube with the beam angulation limited as I have indicated here.

The question I would like to put to the radiologist is this: Is it absolutely imperative, particularly in the region of 400,000 volts upward, to have these high degrees of freedom for the x-ray tube? If you can direct a tube from the horizontal to the vertical and you can at the same time orient the patient in a horizontal plane, it seems to me that you ought to be able to obtain 95 per cent of the desired angulations of your beam without at the same time making it necessary to point the direct beam at more than one of the four walls. I would like very much to get an expression of opinion as to the necessity for this high degree of flexibility, particularly in the upper-voltage region.

R. R. Newell, M.D. (San Francisco, Calif.): I find myself pulled in two directions. One is to lower the accepted level of permissible dose. I get increasingly nervous over allowing anybody to

get 0.1 r a day, day in and day out. I am beginning to think that is too much. On the other hand, I feel sure that there has been a great lack of a sense of humor in designing installations for 1,000,000 and 2,000,000 volts because of the failure to appreciate fully how very much softer the scattered ray is than the direct ray.

Dr. Taylor has pointed out that if you will give up a little bit in flexibility, which need not interfere with treating the patient the way you would like to treat him, you will be able to reduce the cost of expensive installation.

In one installation, the original plan was for a door large enough to allow a patient and bed to be taken into the treatment room. The bid on the door was $20,000. By using a little sense of proportion and calculating how the apparatus was going to be used, it proved possible to reduce that cost to $2,000. The apparatus is now in use and the protection is more than adequate; it doesn't let more than half as much x-ray through as could possibly be dangerous.

G. Failla, Sc.D. (New York): One point that I want to mention is this question of angulation of an x-ray beam. Actually, you need 6 degrees of freedom to treat patients properly—three linear motions and three angulations. How many degrees of freedom you assign to the x-ray machine and how many you assign to the patient is a question of convenience. When the bulk of the machine becomes large, it may be easier to move the patient around. In practice, however, it is found necessary to have at least one angulation assigned to the x-ray tube. If you have that, then all the adjustments can be obtained without too much inconvenience either on the part of the radiologist or on the part of the patient. Unless the patient is comfortable, he is not going to stay in the position in which he has been placed. That is one of the essential things to remember in designing machines; the patient has to stay under the machine or in a certain position for the duration of the treatment. If he shifts, then you are not treating the tumor as you planned to. So one angulation in the tube—that is, one freedom of angular motion—is really an essential feature of an x-ray machine. That, however, as pointed out by Dr. Taylor, does not complicate the protection problem very much, and you still have a flexible installation. On the other hand, if you provide a fixed beam, a vertical beam is always better than a horizontal one, but that is still not satisfactory. What is needed is at least one angulation in one plane from the vertical to the horizontal.

Titus C. Evans, Ph.D. (New York City): I would like to say just a word about the use of radioactive sodium or radioactive phosphorus in the treatment of widespread malignant processes. One of the reasons that we worked with sodium was to compare the effects of this general radiation given internally with that of phosphorus. Not only is there a difference in the distribution in the body but the irradiation is protracted over a two-day period rather than three weeks or something like that. We found that in the same diseases we could duplicate some effects of phosphorus with sodium. As to Dr. Jacox's patient, it is difficult for me to believe, in view of the way in which we followed him, that he was over-dosed. We have to accept results, and we may have to accept this as an indication that this patient should not have received so much radiation. At the same time, we need to reserve judgment, inasmuch as this disease was in the bone and may have had some effect on the depletion of the bone marrow.

Harold W. Jacox, M.D. (*closing*): I think I should answer Dr. Chamberlain, since Dr. Evans partially answered him. The question that he raised was whether to use radioactive sodium or phosphorus. Unless you have a cyclotron at your fingertips you would not be likely to use radioactive sodium because of the short half-life, for you have to use it as soon as you get it. The advantage of phosphorus is obvious—it can be mailed to you. There is also a difference in cost, which may or may not make any difference.

I have one of Dr. Aebersold's booklets and it does not say, "Prices subject to change without notice," but I can give you the latest quotation. I think this is not a secret. P^{32} is $1.10 per millicurie but you don't have to use as many millicuries as you do of Na^{24}, so there would be advantages in using the phosphorus.

About the type of radiation: as Dr. Evans pointed out, we want to find out what effects these substances have, so the other point that Dr. Quimby brought up I think is very good. This was just one case, but I don't know that she knows, and I did not bring it up because I did not know that I had time, that we have another patient, aged nineteen, with sympatheticoblastoma, diagnosed by removing one of his ribs, that is almost a dead ringer for this case and he had nothing but x-ray therapy and is alive and well, with no symptoms, four years after the diagnosis was made histologically. So we did have a comparison in that regard.

I did not mean to say that the patient was overtreated. I don't think he was. We do know in radiotherapy in general that some people are more sensitive than others, and I merely presented this case to show that we don't know all the answers. We are barely scratching the surface. This is just one of our experiences, but it is something for us all to think about. It was one case well studied, however.

Excretion of Radium from the Mouse[1]

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ALTHOUGH THE value of using experimental animals in the study of radium poisoning is recognized, few studies of experimental radium poisoning have been reported (1, 5). We have studied the excretion of radium from mice by a new method and, in addition, have investigated the possibility of influencing excretion of radium by administration of British antilewisite, 2,3-dimercaptopropanol (hereafter referred to as BAL). This compound has previously been found to be of value in the treatment of arsenic (6), mercury (7), and antimony (8) poisoning.

EXPERIMENTAL PROCEDURE

The study of the excretion of radium from the body of experimental animals has always involved tedious methods, such as the measurement of exhaled radon, collection of feces and urine, and the ashing of tissues. A more convenient way is to administer equal doses of radium element to each of a large group of animals, kill several animals at fixed periods after radium administration, seal the animals in glass containers, and measure the gamma radiation a month later. In addition to its simplicity, this method offers the further advantage that the individual tissues can then be studied for radium content and biologic changes progressing from the first day after administration.

One hundred and fifty C3H male mice between five and six months of age were divided into three groups of 50 each. The mice of all groups were injected intraperitoneally with 0.2 c.c. of an aqueous solution, adjusted to pH 5 with HCl, containing approximately 50 micrograms per cubic centimeter radium element as $RaBr_2$ and 200 micrograms per cubic centimeter of $BaCl_2$. The $BaCl_2$ was included to insure complete solution of the $RaBr_2$. Samples of solution were taken for measurement, and two mice of each group were killed and sealed in glass tubes containing 40 per cent formaldehyde immediately after injection to ascertain the dosage.

The mice were kept in cages with wire mesh bottoms and walls to prevent contamination of the fur by excreta.

To study the effect of BAL on radium elimination in the early stages of radium poisoning, the first group of animals was given 0.5 mg. BAL in 0.05 c.c. of sesame oil subcutaneously daily for twenty days beginning two days prior to injection of radium. Beginning with the radium injection and continuing for ten days, two mice were killed daily and sealed in glass tubes containing 40 per cent formaldehyde. After this, two mice were killed every second day for ten days and prepared in the same way. Following this, two mice were killed every fifth day for twenty-five days. The remaining mice were kept until death.

The second group of mice was used to observe the effect of BAL on radium elimination in the late stages of radium poisoning. Beginning the twentieth day after injection of $RaBr_2$, these animals were given BAL subcutaneously in the same amount as that received by the first group. These injections were continued for twenty days. Every day, beginning with the BAL injection and continuing for nine days, two mice were killed and prepared in the way described. Next, two mice were killed every second day for ten days, and then two mice every fifth day for twenty-five days. The remaining mice were kept until death.

[1] This paper is based in part on work performed under contract number W-31-109-eng-38 for the Manhattan Project at the Argonne National Laboratory. Received for publication in November 1947.

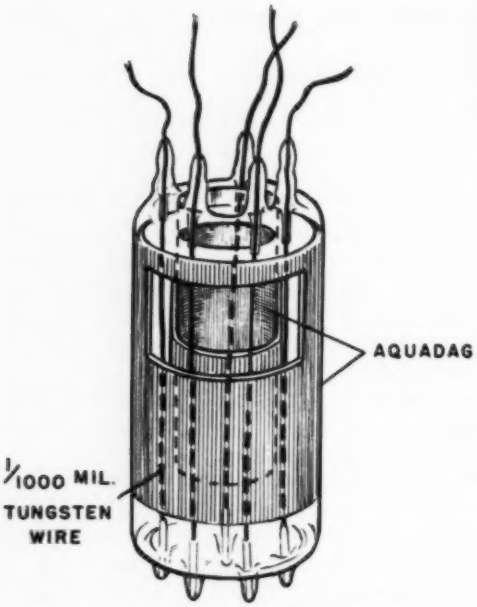

Fig. 1. Multiple Geiger-Müller counter.

The third group was not given BAL. Two mice of this group were killed every second day for thirty days and then two every fifth day for twenty-five days. As in the case of the first two groups, the remaining animals were kept until death and were then immediately measured for trapped radon.

After the radium content of the mice was determined, several tubes containing mice from Group 1 were opened. A few tissues (spleen, lungs, kidneys, liver, and part of the vertebral column) were taken, weighed, and sealed in separate glass tubes, in order to obtain an idea of the distribution of the radium.

Method of Measurement: The amount of radiation from the mice and the tissues was so small that, to get accurate results, measurement with a single counter would require extremely long counting periods. A modification of the Geiger-Müller counter was therefore devised for these measurements.

By surrounding the sample to be measured with a circle of self-quenching counters connected in parallel, a much larger percentage of the radiation is utilized. With all cathodes adjacent and placed in a single housing, approximately 300 per cent more radiation is measured than with a single counter in close proximity to the source. Moreover, when the circle of counters is replaced by two concentric cylindrical cathodes between which are placed wire anodes equidistant from each other, a simple modification of the Geiger-Müller counter for measuring samples of low gamma-ray intensity is obtained (Fig. 1).

The total amount of radium in the mice was measured with a circle of counters, while the radium content of the tissues was measured with a concentric double-cylinder counter. The large multiple counter for the mice consisted of 13 oxidized nickel cylinders 15 cm. long and 15 cm. in diameter arranged in a circle and contained in a glass housing of two concentric cylinders the inside diameter of which was 4 cm. This counter was put into a lead shield 4 cm. thick, thus cutting the background down by 70 per cent. It was used in conjunction with a counting rate meter (9).

Radium standards received from the National Bureau of Standards were used for comparison. They consisted of a known aqueous solution of radium bromide in ampules 26 mm. in diameter and 116 mm. long, the same size as the glass tubes containing the mice.

The error due to internal absorption of radium C gamma rays by the mouse or solution was overcome by enclosing both the standard and the tube containing the mouse in a lead shield of 3 mm. thickness while the measurements were made, thus cutting out the soft gamma ray component. The error due to statistical fluctuation in the counting setup was ± 1 per cent for 2 micrograms.

The counter for measuring the radium content of the tissues consisted of two concentric cylindrical cathodes of aquadag and four tungsten wire anodes spaced evenly between the two cylinders. The diameter of the inside cylinder was 2.8 cm. and that of the outside cylinder 5.8 cm.;

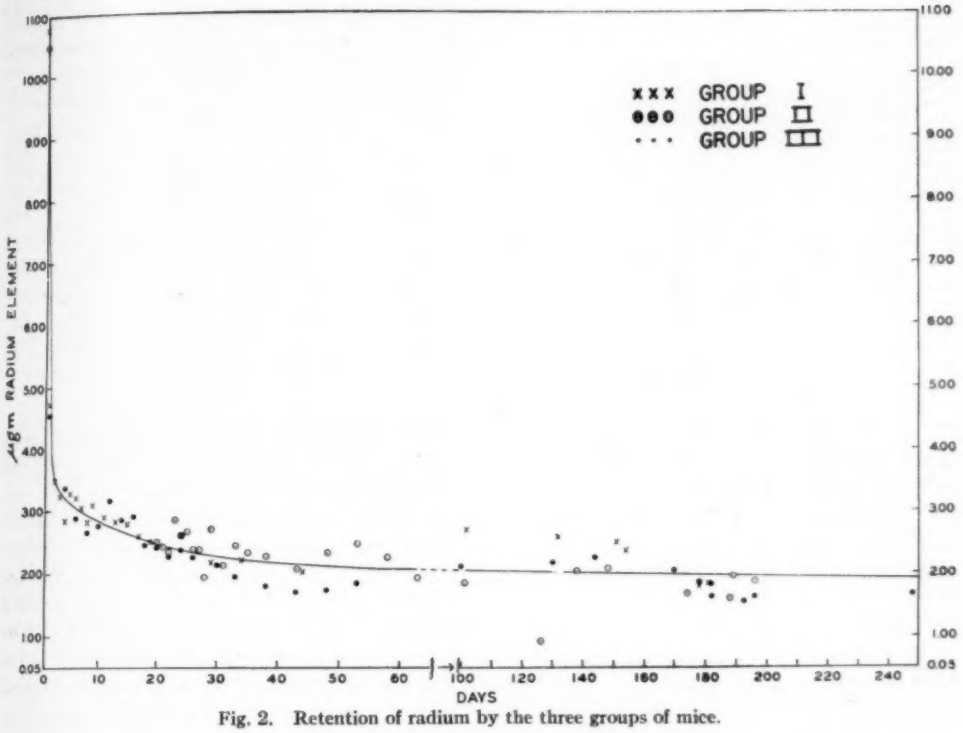

Fig. 2. Retention of radium by the three groups of mice.

they were 11 cm. long. Like the large multiple counter, this four-wire counter was placed in a lead shield 4 cm. thick, which reduced the background by about 56 per cent.

The standards used for comparison were ampules containing known amounts of radium halide in aqueous solution. These ampules were 16 mm. in diameter and 68 mm. long, as were the tubes containing the tissue. The tissues and the standards were enclosed in 3-mm. lead shields to cut out the soft gamma ray components. They were placed in the center cylinder of the counter, and the radiation was measured with the counting rate meter.

With this counter the probable error due to statistical deviation ranged from 4 per cent at 0.1 microgram to 7 per cent at 0.025 microgram. The error in measuring less than 0.025 microgram increased rapidly as the counting rate due to the background overtook the counting rate due to the sample.

RESULTS

The spread of the points due to biologic variation is great enough so that the three curves representing the retention of radium by the mice in the three groups lie well within the range of variation. Therefore, the points for all three groups were plotted together and a mean elimination curve was drawn (Fig. 2). Each point on the graph up to seventy days represents the average of measurements on two mice; after that the points represent single observations.

The BAL had no observable effect. Apparently a large part of the radium is not absorbed by the system, for at the end of the first day only 51.9 per cent of the radium injected remained and at the end of the second day only 33.0 per cent. Five days after injection 29.2 per cent remained. By fifty days 19.8 per cent was still retained, and the rate of elimination seemed to have reached a steady state of 0.01 per cent per day. These figures, of course, represent the average.

TABLE I: RADIUM CONTENT OF TISSUES

Number of Days after Injection	Total Amount of Radium in Mouse, in Micrograms	Radium in Micrograms				
		Lungs	Liver	Kidneys	Spleen	Vertebral column (6 vertebrae)
1	5.0	0.005	0.062	0.028	0.043	0.130
1	4.5	0.01	0.072	0.026	0.048	0.194
8	2.70	0.003	0.027	0.003	0.013	0.181
8	2.92	0.003	0.012	0.003	0.012	0.138
15	3.12	<0.001	0.01	0.003	0.011	0.121
15	2.48	0.003	0.007	0.005	0.003	0.141
24	2.94	<0.001	0.01	0.002	0.007	0.10
24	2.30	<0.001	0.006	0.003	0.003	0.106
44	1.98	0.004	0.016	0.003	0.004	0.103
44	2.06	0.012	0.018	0.01	0.016	0.107
102	2.7	<0.001	0.01	<0.001	<0.001	0.135
132	2.6	0.003	0.007	<0.001	0.003	0.089

One hundred days following injection, the mice began to die. In addition to the usual radiation effects, such as weight loss, some tumorous growths on the side of the jaw were observed. To date, however, no histologic studies have been made, and the occurrence of osteogenic sarcoma is not known.

At death the mice contained from 2.7 to 0.92 micrograms, or from 25.7 to 8.7 per cent of the radium injected. The amount of trapped radon ranged from 35 to 7 per cent, with an average of 19.7 per cent.

Many of the tissues had too little radium to measure accurately by the gamma-ray method used. Nevertheless, a general picture of the distribution was obtained. Table I shows the total radium content of the tissue, while Table II shows the radium content per gram of tissue. (The figures in Table II represent the radium content per gram of formaldehyde-fixed tissue and hence can be used only in comparing the relative amounts in these organs.) Table I is presented primarily to show in which measurements a large error occurs, as the error in measuring is appreciable at amounts less than 0.025 microgram and is about ±70 per cent at 0.005 microgram.

At the end of the first day, maximum amounts of radium are localized in the various organs and tissues. The radium is subsequently eliminated from the organs at a rate dependent on the individual tissue. After the first day, most of the retained radium is in the bone and is thereafter eliminated very slowly. The content of the spleen is also high at first, but the elimination rate here is rapid. By the end of the first week, the radium content of the liver and kidneys seems to have reached constant level, although the variations are considerable. The lungs show too great a variation in radium content and the error was too high to permit conclusion. No radium was found in the formaldehyde used for fixation, indicating that the radium had not diffused out of the tissue.

DISCUSSION

In this series of experiments, an average of 19 per cent of the radium injected intraperitoneally had been retained by the mice dying 100 to 240 days after injection. Evans, Harris, and Bunker (1) found that at the time of death rats retained an average of 3 per cent of the radium administered orally and about 78 per cent of that injected intradermally. The high retention after intradermal injection was explained by the fact that some radium was trapped at the site of injection and was not absorbed by the system. It was calculated that about 50 per cent of the radium reaching circulation was retained. The low percentage retained after oral administration suggests that a large part of the radium fed was excreted immediately and never reached circulation. The actual percentage retention of radium seems to depend in large part on the route of intake and thus means little except in comparing results

TABLE II: RADIUM CONTENT PER GRAM OF TISSUE

Number of Days after Injection	Total Amount of Radium in Mouse, in Micrograms	Ra/Gram Tissue in Micrograms × 10^3				
		Lungs	Liver	Kidneys	Spleen	Vertebral Column
1	5.0	13.2	40.0	56.8	650	677
1	4.5	21.6	49.0	69.2	750	684
8	2.74	3.9	15.6	5.6	120	642
8	2.92	6.9	6.7	6.5	142	616
15	3.12	0	6.02	5.55	68.8	652
15	2.48	4.03	4.03	10.2	30.4	568
24	2.98	0	6.12	4.05	72.2	495
24	2.06	0	2.17	6.1	21.5	443
44	1.98	7.14	10.3	6.4	42	532
44	2.06	29.9	12.2	23.3	144	448
102	2.7	0	9.2	0	0	549
132	2.6	11.5	5.1	0	0	452

obtained following comparable methods of administration.

The average excretion rates in the late stage, of 0.035 per cent per day as found by Evans and co-workers (1) and of 0.09 per cent per day as determined by Thomas and Bruner (5), both groups working with rats, are higher than the average excretion rate of 0.01 per cent obtained in mice.

Contrary to common belief (10), the radium does not accumulate slowly in the bone, but, after a single injection, reaches the maximum concentration within twenty-four hours. It is also fixed in the soft tissues quite rapidly. Elimination from the bone, however, is extremely slow, while elimination from the soft tissues is rapid. Evans and his co-workers observed the lungs to be the richest soft tissues; Thomas and Bruner found the kidneys to contain more radium than other soft tissues but also found the lungs to be rich in radium. The great variation in the content of the tissues taken from mice in the late stage of radium poisoning makes any statement as to the relative concentration in the tissues impossible.

The value of BAL in treatment of certain heavy metal poisoning is the fact that BAL competitively removes the metal from its combination with tissues, the detoxication effect thus being accompanied by an increase in the excretion rate. Because the radium apparently did not combine with the BAL, either in the early or late stage, and because no radium was found in the fixing fluid, the assumption that radiocolloids were formed in the system might be made. This assumption is strengthened by recent observations of Gofman (11), who found that colloids of radioactive zirconium and yttrium localized in a short time preferentially in bone and spleen when the particle size was less than 1 micron.

SUMMARY

Excretion of radium following intraperitoneal injection was studied in three groups of strain C3H mice. Two groups were given British anti-lewisite (BAL) as a possible means of increasing the elimination rate. In addition, the radium content of a few organs of selected mice of one group was obtained.

An average of 19 per cent of the injected radium remained in the mouse at death 100 to 240 days after injection. The average elimination rate of 0.01 per cent per day in the chronic stage agrees well with that found by other observers when such factors as species differences are taken into consideration.

The radium was found to concentrate in the bone shortly after injection. It was eliminated from the bone only slowly, but elimination from the soft tissue, notably the spleen, was rapid. The observations are at variance with those of Evans *et al.* in that the lungs contained very little radium.

BAL as here administered had no effect on the rate of elimination.

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SUMARIO

Excreción de Bario en el Ratón

En tres grupos de ratones de cepa C_3H se observó la excreción de radio después de la inyección intraperitoneal. Como posible medio de acrecentar la tasa de eliminación dos grupos recibieron anti-lewisita inglesa (BAL). Además, se determinó el contenido de bario en algunos órganos de ratones seleccionados de un grupo.

A la muerte, de 100 a 240 días después de la inyección, permanecía en el ratón un promedio de 19 por ciento del radio inyectado. El coeficiente medio, de 0.01 por ciento diario de eliminación en el período crónico, concuerda con el descubierto por otros observadores.

Notóse que el radio se concentraba en el hueso poco después de la inyección. Del hueso era eliminado lentamente, pero la eliminación de los tejidos blandos, y notablemente el bazo, era rápida. Estas observaciones discrepan de las de Evans y colaboradores, en que los pulmones contenían muy poco radio.

La BAL, tal como se administró en este estudio, no afectó la velocidad de la eliminación.

Highlights of the Past and a Challenge for the Future[1]

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I AM OF COURSE deeply gratified to have my name assigned to this laboratory, which is to be devoted to a field in which I have worked for so large a part of my life. Laboratory work has always fascinated me because of the unexpectedness of what may be found and of the application which may be made of the discoveries. No more important example of the unexpected can be found than Roentgen's discovery of the x-rays. This was nearly fifty-three years ago and was one of the great steps leading up to the present atomic age.

This discovery enlarged tremendously the known spectrum of radiant energy, which had previously been carried only from what we now call radio waves to heat and light, including the ultraviolet. The nature of the new radiations, at first unknown, was found also to be electromagnetic, thus joining them to the short-wavelength end of the previously known spectrum, that is, to the ultraviolet.

Prior to Roentgen's discovery we had talked of a hypothetical indivisible and indestructible atom, and had recognized in the various chemical elements 88 different kinds of atoms. We had long been aware of a certain periodicity in the properties of these atoms but could only wonder why this was so. X-ray research showed the reason—that the atoms of the various elements all consist of the same building blocks and differ only in the number and arrangement of these particles, which we now recognize as electrons, protons, and neutrons. Our hypothetical atom, that indivisible particle of matter, was found to consist of a whole swarm of smaller particles, more than 300 in the case of the heaviest elements.

We have thought that there were only as many kinds of atoms as there are chemical elements, but we know today that each chemical element may occur in several different atom forms (isotopes) and we now list some seven hundred different kinds of atoms.

In the year following Roentgen's discovery, radioactivity was first observed. It was in the case of uranium, whose atoms proved to be unstable and spontaneously to undergo a series of internal changes until they finally become lead, thus exploding the idea of inherent permanence of the atom.

We had felt very sure of the conservation of mass. If you burned a weighed piece of wood, weighed the remaining ash, and took account of the gases which came off, you found no diminution in total weight. We know now that mass may disappear as such, reappearing as energy, and that the two are mutually interchangeable. Were our measurements sufficiently precise, we would find, when we burn a piece of wood, that there is a loss in weight and that it corresponds exactly to the heat energy liberated. The weight loss would, however, in this case be relatively too small to show on even our most delicate balances, as it would amount to only about a ten thousandth of a millionth of the weight of the wood. We are here dealing with a chemical reaction in which nuclear changes are not involved. Where nuclear changes do take place, the loss of mass may be relatively enormous and the radiated energy correspondingly large.

It was shown that, by bombardment of various chemical elements with high-energy particles or with multimillion-volt x-rays, nuclear changes could be made to take place which would release energy, but the process involved was so inefficient that there was no net gain but always a net loss

[1] Presented at the dedication of the Wm. D. Coolidge Laboratory, General Electric X-Ray Corporation, Milwaukee, Wis., Sept. 13, 1948.

of energy. This same condition pertained even after the discovery of uranium fission with its tremendous energy release. It would still have taken so much energy to produce neutrons for the bombardment that there would have been no net gain of energy. In this case, however, it developed that, under favorable conditions, the process once started would go on of itself, due to the fact that the neutrons required for its continuance were supplied by the fission. This made possible both the explosive atom bomb and the chain-reacting pile with its controlled energy release.

Until some years after Roentgen's discovery, we thought that no electric current could flow through a vacuum. This had apparently been demonstrated many times, especially by the roentgenologist, who had found that the vacuum of his gas tubes usually improved with use and that, if it became too good, the tubes would pass little or no current. This had also been the experience of the physicist in working with the earlier Geissler and Crookes tubes.

Edison, on the other hand, had observed, in the incandescent lamp, a flow of current from one end of the hot filament to the other, across the vacuous space. This effect, which we now ascribe to thermionic electron emission, was quantitatively studied by Richardson. However, most physicists of that day believed that the effect was due to gas contained in the hot body, and that no current would flow through a high vacuum once the cathode had lost its gas. Again the roentgenologist, and the x-ray tube manufacturer as well, seemed to have strong evidence, and it was in support of this gas theory, for with use, x-ray tubes became unstable, so that they would not continuously carry current even though fresh gas were repeatedly admitted. When this condition had been reached, the cure consisted in rebuilding the tube, with the introduction of a new gas-containing aluminum cathode.

More than a quarter of a century after Edison's observations, Dr. Langmuir, working in our laboratory with hot tungsten filaments, which, because of their high melting point, he was able to preheat to a very high temperature to free them from gas, found that their thermionic emission was then stable and reproducible and even favored in amount by freedom from gas. He also showed that the current is in general determined not solely by the thermionic electron emission but that it is limited by the mutual repulsion of the electrons—that is, by the space charge. This made possible not only a new x-ray tube but also a whole family of other high-vacuum tubes.

Speaking of high vacuum, in our views of matter, we had thought of ordinary solids as being very dense, as they were only slightly compressible. But we are now able to weigh the constituent particles of matter, the electrons, protons, and neutrons, and in other ways to determine their effective size, and so we learn that the density of nuclear matter is nearly ten million tons per cubic inch, and all of the things which we had regarded as solid are really high-vacuum peppered with tiny dense particles. Where these same particles are much closer together, as in some stars, a cubic inch of material has been found to weigh as much as 10 tons. Eddington has pointed out that if the electrons, protons, and neutrons comprising a human body could be brought into actual contact with one another, with the consequent elimination of the vacuous space between them, it would readily be visible only with the aid of the microscope.

Following closely along with these and other fundamental discoveries, has gone the development of powerful new physical tools and chemical methods. The art of electronics has entered most technical fields of activity and that of nucleonics is developing rapidly.

The x-ray art has made rapid strides, as may be seen, for example, from the progress made in increasing the voltage and hence the range of penetrating power. In this, we were at first limited to a few hundred thousand volts by what was then a new phenomenon—by the appearance of what we have since come to call field currents. These were due to electrons pulled

out of those areas of the cathode where the potential gradient was highest. They increased rapidly with voltage, did not respond to the control of the hot cathode discharge, were in general not brought to the same focus as the latter, and were therefore highly undesirable.

High-voltage generators are now built for as much as several million volts, and to produce x-rays of still higher energy, we have the betatron and synchrotron. Looking ahead, the linear accelerator, which is undergoing development, may later become a successful competitor of the latter.

The penetrating power of the x-rays increases up to several million volts, reaching its maximum at different values for different materials, and then slowly decreases for further increase in voltage.

Multimillion-volt x-rays cause nuclear disintegrations including fission. Their absorption in matter is largely due to electron pair formation, a process entirely lacking at voltages of less than a million.

With x-rays of a couple of thousand volts the internal structure of exceedingly delicate objects can be shown, and with as much as ten million volts, excellent radiographs can be made through a foot or more of steel.

In the hands of the medical profession, the x-rays have become an important therapeutic agent, and the scope of their usefulness in this field seems to have increased with increase in voltage up to at least several hundred thousand volts. Whether this will later extend to millions of volts can be determined only by the medical profession.

As x-rays are capable of destroying all living tissue, it is indeed fortunate that they can safely be used for the medical diagnosis of human ailments. For this, we must thank those who have developed special photographic film and sensitive screens.

It would be a convenience, however, for medical diagnosis, if a much more sensitive receiving system than the simple fluoroscopic screen or intensifying screen and film could be developed. Much effort is being devoted to a study of various electronic methods of intensifying the screen luminosity. Of these methods, the combination of fluorescent screen and electron image tube would seem today to offer the greatest promise.

The viewing of the fluorescent screen image by television has been often suggested, but even with the most sensitive camera tube (image orthicons) this has not as yet looked attractive for medical application as, with x-ray intensities used in fluoroscopy, the luminosity of present fluoroscopic screens is too low to give a useful television image.

For industrial use, however, there would be no objection to using high x-ray intensities to get a sufficiently high luminosity of the fluorescent screen which could then perhaps advantageously be viewed by television.

It has developed that the x-rays in sufficient dosage not only destroy all human tissues but, in smaller and oft repeated doses, are capable of producing cancer. As years may elapse between the exposure and the development of the malignant growth, a very considerable time period was needed to show the danger. As a result, a number of the pioneers in the medical use of the x-rays suffered greatly and eventually died from their x-ray injuries. We can say today that the world owes them a great debt of gratitude, for in the absence of this demonstration of the danger of too much exposure to penetrating radiation, a great many lives might have been, and almost certainly would have been, lost through exposure to the relatively enormous intensity of radiation from the chain-reacting piles. Actually, the great piles at Hanford and the apparatus for the chemical treatment of the intensely radioactive materials which must be processed there were so designed and constructed, and have been so operated, that no one has ever been injured there from the radiation. The magnitude of the protection problem which had to be dealt with at Hanford may be sensed from the fact that at Hiroshima, within a range of a half mile from where the

bomb exploded, people must have received a lethal dose of penetrating radiation in those first few millionths of a second during which the intensity was highest.

In all of our work, both for the production of x-rays and for the development of the many accessories needed for their medical applications, we have had helpful and indispensable co-operation from the medical profession. This co-operation has been mutually helpful, each party having always contributed useful knowledge and special experience to the other. We have supplied some knowledge of physical and engineering principles, while the medical specialists have supplied the knowledge of anatomy and pathology together with skill in the radiographic and therapeutic arts. Without such co-operation between our own and other industrial groups on the one hand and the medical profession on the other, the rapid development which has taken place would have been impossible.

To speak now of this laboratory which we are dedicating today: We see the building and certain experimental facilities and call it a laboratory, but that is like calling a skeleton a man. In the old Japanese Kabuki plays, properties were changed on the stage in full view of the audience, but the men making the changes were dressed in black so that they should not distract attention from the actors. Here perhaps the walls and facilities should have been black for today, so that you would have seen only the young scientists and engineers who will be working here, for it is they who deserve the spotlight. And may I bespeak for them the co-operation of those who may at any time be interested in the development of new medical x-ray equipment.

The only predictions for the future which I will make are: first, that fundamental research, which is now receiving much of the attention and support which it merits, will, as in the past, and with increasing tempo, supply new scientific facts and principles; and second, that this laboratory, designed for applied research and development, will, with the co-operation of the medical profession, promptly and effectively use such new discoveries to extend and strengthen the x-ray art.

May this new laboratory play a worthy role in helping the medical profession in its beneficent contribution to human health and happiness.

SUMARIO

Las Cumbres del Pasado y el Reto al Porvenir

En el discurso pronunciado por el Dr. W. D. Coolidge en la dedicación del Laboratorio William D. Coolidge en el establecimiento de la General Electric X-Ray Corporation en Milwaukee, Wis., E. U. A., repásanse algunas de las modificaciones radicales que han tenido lugar en nuestros conceptos de la materia y la energía debido al descubrimiento de los rayos X por Roentgen, los adelantos tecnológicos en la ciencia radiológica y las proezas médicas de esta última.

Hácense dos profecías: "primero, que la investigación fundamental, que hoy día recibe, en gran parte, la atención y apoyo que merece, suministrará, lo mismo que en el pasado, pero con ritmo creciente, nuevos datos y principios cientificos; y segundo, que este laboratorio, dedicado a la investigación y el desarrollo aplicados, utilizará, con la colaboración de la profesión médica, pronto y efectivamente los nuevos descubrimientos para extender y fortalecer el arte roentgenológico."

EDITORIAL

Primum Non Nocere

Approximately fifteen years have elapsed since the first publication called attention to the use of thorium dioxide sol injection into human beings for radiographic delineation of an organ. Within the last ten years, evidence has been steadily accumulating to the effect that this is a harmful procedure, and the occasional diagnostic advantages of its use do not warrant the risk. In an editorial which appeared in RADIOLOGY in 1933, attention was called to the fact that, at that time, many publications had been made condemning the use of this medium. Attention was also called to the fact that the manufacturers were fair in their claim for it, inasmuch as they plainly stated that further investigation by the medical profession was recommended before it be accepted. At that time, developments in the measurement of radioactive substances had not progressed to the point where they were readily made, but it was generally believed that the introduction of this radioactive material into the human body could cause damage by a long-continued intracellular radiation. In 1937, an article by Taft appeared in the *Journal of the American Medical Association*, in which the standard dose (75 c.c.) of thorotrast was compared with standard samples of radium. It was stated that the radioactivity from this dose of thorotrast was remarkably close to that arising from small amounts of radium which had accidentally been received, with fatal results.

At about that time, a number of workers discontinued the use of thorotrast but the discontinuance was by no means universal.

The *Lancet*, for June 1936, had an article by Selbie, describing experimental work in which small amounts of thorotrast, injected subcutaneously into rats, produced malignant tumors in a large number of the animals. Even at that time, Selbie stated that thorotrast should never be introduced into the human body, because of the danger of inducing tumors.

It might appear that thorotrast would be a satisfactory medium for injection into the lactic ducts in order to delineate the breast radiographically, but an article in the *Journal of the American Medical Association*, by Mora, in 1940, reported that this material acts as a foreign body and causes symptoms which are obviously not the result of radioactivity.

An article in the *American Journal of Pathology* for July 1947, by MacMahon, Murphy and Bates, offers indisputable evidence of the development of endothelial-cell sarcoma of the liver twelve years after the injection of thorotrast.

In the present issue of RADIOLOGY (page 831) appears an article in which attention is called to the extreme danger of this medium in perivascular tissues, where it was accidentally placed, instead of within the artery. The serious results following this are well worthy of consideration.

It is at least encouraging to notice that the February *Journal of the American Medical Association* carried an article on angiography, by Wechsler and Gross, who state that thorotrast should not be used, as diatrast has been found perfectly satisfactory.

It appears, in summary, that there is preponderant evidence to the effect that the dangers of thorotrast greatly outweigh its occasional diagnostic advantages.

This advice appears as timely now as in the past—in dealing with human beings, first make sure that you do no harm.

ROBERT B. TAFT, M.D.

ANNOUNCEMENTS AND BOOK REVIEWS

AMERICAN COLLEGE OF RADIOLOGY

The American College of Radiology has announced the resignation of Mr. Mac F. Cahal as Executive Secretary and the appointment of Mr. William C. Stronach to serve in that capacity. Mr. Cahal has accepted an appointment as General Counsel and Executive Secretary of the American Academy of General Practice.

CONNECTICUT VALLEY RADIOLOGIC SOCIETY

Among the latest additions to the roster of radiological societies is the Connecticut Valley Radiologic Society, organized in March 1948. Dr. G. W. Heublein, Hartford, Conn., was elected President; Dr. John W. Turner, Springfield, Mass., Vice-President, and Dr. Ellwood W. Godfrey, 1676 Boulevard, West Hartford, Conn., Secretary. Meetings are planned for the second Friday of October and April in varying locations.

At the fall meeting, Oct. 8, in the auditorium of the Hartford Hospital, Dr. Edward B. D. Neuhauser of the Children's Hospital of Boston, assisted by Drs. Green, Wittenborg, and Pickett, of the staff of the same institution, presented a stimulating symposium on "Congenital Malformations of the Heart and Great Vessels Amenable to Surgery."

Dr. E. P. Pendergrass, of Philadelphia, is scheduled to address the April meeting.

Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

NUCLEAR RADIATION PHYSICS. By R. E. LAPP, PH.D., Research and Development Board, Washington, D. C., and H. L. ANDREWS, PH.D., National Institute of Health, Bethesda, Md. A volume of 488 pages, with numerous illustrations. Published by Prentice-Hall, Inc., New York. Price $6.00.

THE DIGESTIVE TRACT IN ROENTGENOLOGY. By JACOB BUCKSTEIN, M.D., Assistant Professor of Clinical Medicine, Cornell University Medical College; Visiting Roentgenologist (Alimentary Tract Division), Bellevue Hospital, New York City; Attending Gastro-enterologist, Beth David Hospital, New York City; Consultant in Gastro-enterology, Central Islip State Hospital, New York; Formerly Consultant in Gastro-enterology to the U. S. Public Health Service and the U. S. Veterans Bureau. A volume of 890 pages, with 1030 illustrations in 659 figures. Published by J. B. Lippincott Company, Philadelphia. Price $16.00.

DIE INDIKATIONEN ZUR RÖNTGEN- UND RADIUM-BESTRAHLUNG. By DR. MED. HABIL. R. GLAUNER, Dozent für Röntgenologie und Strahlenheilkunde, Stuttgart. A volume of 128 pages. Published by George Thieme, Stuttgart. 1948. In paper cover DM 7.20.

Book Reviews

CLINICAL ROENTGENOLOGY OF THE DIGESTIVE TRACT. By MAURICE FELDMAN, M.D., Assistant Professor of Gastroenterology, University of Maryland; Associate in Gastroenterology, Mercy Hospital; Consulting Roentgenologist, Sinai Hospital. A volume of 902 pages, with 641 illustrations. Published by Williams & Wilkins Company, Baltimore. 3rd ed., 1948. Price $8.00.

Feldman's valuable text on "Clinical Roentgenology of the Digestive Tract" has now, within ten years of its original publication, reached its third edition. In general the new edition follows the plan of the two preceding editions, but the text has been revised and new illustrations have been added.

In dealing with the various lesions of the gastro-intestinal tract, the author has laid considerable emphasis on the clinical aspects, without, however, neglecting the roentgen study. Liberal recognition is made of the work of others, and a pertinent bibliography is appended to each chapter, including references to many recent articles.

Beginning with a chapter on the Esophagus, the author proceeds to discuss all parts of the gastro-intestinal tract, including the various abdominal organs in addition to the hollow viscera. Chapters are also devoted to lymphomatous diseases, retro-peritoneal tumors, and deficiency diseases. The text is readable, informative, and concise, though occasionally one feels that the discussion of some particular lesion is a little sketchy. The illustrations are of good quality and well reproduced.

Those interested in the roentgenologic study of the gastro-intestinal tract will find this volume a valuable source of information.

RADIOLOGICAL SOCIETIES: SECRETARIES AND MEETING DATES

Editor's Note: Secretaries of state and local radiological societies are requested to co-operate in keeping this section up-to-date by notifying the editor promptly of changes in officers and meeting dates.

UNITED STATES

RADIOLOGICAL SOCIETY OF NORTH AMERICA. *Secretary-Treasurer*, Donald S. Childs, M.D., 713 E. Genesee St., Syracuse 2, N. Y.

AMERICAN RADIUM SOCIETY. *Secretary*, Hugh F. Hare, M.D., 605 Commonwealth Ave., Boston 15, Mass.

AMERICAN ROENTGEN RAY SOCIETY. *Secretary*, Harold Dabney Kerr, M.D., Iowa City, Iowa.

AMERICAN COLLEGE OF RADIOLOGY. *Secretary*, William C. Stronach, 20 N. Wacker Dr., Chicago 6, Ill.

SECTION ON RADIOLOGY, A. M. A. *Secretary*, U. V. Portmann, M.D., Cleveland Clinic, Cleveland 6, Ohio.

Alabama

ALABAMA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, W. D. Anderson, M.D., 2501 6th St., Tuscaloosa.

Arkansas

ARKANSAS RADIOLOGICAL SOCIETY. *Secretary*, Fred Hames, M.D., Pine Bluff. Meets every three months and at meeting of State Medical Society.

California

CALIFORNIA MEDICAL ASSOCIATION, SECTION ON RADIOLOGY. *Secretary*, Sydney F. Thomas, M.D., Palo Alto Clinic, Palo Alto.

LOS ANGELES RADIOLOGICAL SOCIETY. *Secretary*, Moris Horwitz, M.D., 2009 Wilshire Blvd., Los Angeles 5. Meets second Wednesday of each month at County Society Bldg.

NORTHERN CALIFORNIA RADIOLOGICAL CLUB. *Secretary*, Charles E. Grayson, M.D., Medico-Dental Bldg., Sacramento 14. Meets at dinner last Monday of September, November, January, March, and May.

PACIFIC ROENTGEN SOCIETY. *Secretary*, L. Henry Garland, M.D., 450 Sutter St., San Francisco 8. Meets annually with State Medical Association.

SAN DIEGO ROENTGEN SOCIETY. *Secretary*, R. F. Niehaus, M.D., 1831 Fourth Ave., San Diego. Meets first Wednesday of each month.

X-RAY STUDY CLUB OF SAN FRANCISCO. *Secretary*, Ivan J. Miller, M.D., 49 Fourth St. Meets monthly on the third Thursday at 7:45 P.M., January to June at Lane Hall, Stanford University Hospital, and July to December at Langley Porter Clinic, University of California Hospital.

Colorado

COLORADO RADIOLOGICAL SOCIETY. *Secretary*, Mark S. Donovan, M.D., 306 Majestic Bldg., Denver 2. Meets third Friday of each month, at the Colorado School of Medicine and Hospitals.

Connecticut

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY. *Secretary*, Robert M. Lowman, M.D., Grace-New Haven Hospital. Grace Unit. New Haven. Meetings bimonthly, second Thursday.

CONNECTICUT VALLEY RADIOLOGIC SOCIETY. *Secretary*, Ellwood W. Godfrey, M.D., 1676 Boulevard, W. Hartford. Meets second Friday of October and April.

District of Columbia

RADIOLOGICAL SECTION, DISTRICT OF COLUMBIA MEDICAL SOCIETY. *Secretary*, Alfred A. J. Den, M.D., 1801 K St., N. W., Washington 6. Meets third Thursday, January, March, May, and October, at 8:00 P.M., in Medical Society Auditorium.

Florida

FLORIDA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, F. K. Hurt, M.D., Riverside Hospital, Jacksonville. Meets in April and in November.

Georgia

GEORGIA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Robert Drane, M.D., De Renne Apartments, Savannah. Meets in November and at the annual meeting of State Medical Association.

Illinois

CHICAGO ROENTGEN SOCIETY. *Secretary*, T. J. Wachowski, M.D., 310 Ellis Ave., Wheaton. Meets at the Palmer House, second Thursday of October, November, January, February, March, and April, at 8:00 P.M.

ILLINOIS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly as announced.

ILLINOIS STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY. *Secretary*, Harold L. Shinall, M.D., St. Joseph's Hospital, Bloomington.

Indiana

INDIANA ROENTGEN SOCIETY. *Secretary-Treasurer*, William M. Loehr, M.D., 712 Hume-Mansur Bldg., Indianapolis 4. Annual meeting in May.

Iowa

IOWA X-RAY CLUB. *Secretary*, Arthur W. Erskine, M.D., 326 Higley Building, Cedar Rapids. Meets during annual session of State Medical Society.

Kansas

KANSAS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Anthony F. Rossitto, M.D., Wichita Hospital, Wichita. Meets annually with State Medical Society.

Kentucky

KENTUCKY RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Sydney E. Johnson, M.D., 101 W. Chestnut St., Louisville.

LOUISVILLE RADIOLOGICAL SOCIETY, *Secretary-Treasurer*, Everett L. Pirkey, Louisville General Hospital, Louisville 2. Meets second Friday of each month at Louisville General Hospital.

Louisiana

LOUISIANA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Johnson R. Anderson, M.D., No. Louisiana Sanitarium, Shreveport. Meets with State Medical Society.

ORLEANS PARISH RADIOLOGICAL SOCIETY. *Secretary*, Joseph V. Schlosser, M.D., Charity Hospital of Louisiana, New Orleans 13. Meets first Tuesday of each month.

SHREVEPORT RADIOLOGICAL CLUB. *Secretary*, Oscar O. Jones, M.D., 2622 Greenwood Road. Meets monthly September to May, third Wednesday.

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BALTIMORE CITY MEDICAL SOCIETY, RADIOLOGICAL SECTION. *Secretary*, J. Howard Franz, M.D., 1127 St. Paul St., Baltimore 2.

Michigan

DETROIT X-RAY AND RADIUM SOCIETY. *Secretary-Treasurer*, E. R. Witwer, M.D., Harper Hospital, Detroit 1. Meetings first Thursday, October to May, at Wayne County Medical Society club rooms.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS. *Secretary-Treasurer*, R. B. MacDuff, M.D., 220 Genesee Bank Building, Flint 3.

Minnesota

MINNESOTA RADIOLOGICAL SOCIETY. *Secretary*, C. N. Borman, M.D., 802 Medical Arts Bldg., Minneapolis 2. Meets in Spring and Fall.

Missouri

RADIOLOGICAL SOCIETY OF GREATER KANSAS CITY. *Secretary*, Wm. M. Kitchen, M.D., 1010 Rialto Building, Kansas City, 6, Mo. Meetings last Friday of each month.

ST. LOUIS SOCIETY OF RADIOLOGISTS. *Secretary*, Edwin C. Ernst, M.D., 100 Beaumont Medical Bldg. Meets on fourth Wednesday, October to May.

Nebraska

NEBRASKA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Ralph C. Moore, M.D., Nebraska Methodist Hospital, Omaha 3. Meets third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

New England

NEW ENGLAND ROENTGEN RAY SOCIETY. *Secretary-Treasurer*, George Levene, M.D., Massachusetts Memorial Hospitals, Boston. Meets monthly on third Friday at Boston Medical Library.

New Hampshire

NEW HAMPSHIRE ROENTGEN SOCIETY. *Secretary-Treasurer*, Albert C. Johnston, M.D., Elliot Community Hospital, Keene. Meetings quarterly in Concord.

New Jersey

RADIOLOGICAL SOCIETY OF NEW JERSEY. *Secretary*, Raphael Pomeranz, M.D., 31 Lincoln Park, Newark 2. Meetings at Atlantic City at time of State Medical Society and midwinter in Newark.

New York

ASSOCIATED RADIOLOGISTS OF NEW YORK, INC. *Secretary*, William J. Francis, M.D., East Rockaway.

BROOKLYN ROENTGEN RAY SOCIETY. *Secretary-Treasurer*, Abraham H. Levy, M.D., 1354 Carroll St., Bklyn. 13. Meets fourth Tuesday of every month, October to April.

BUFFALO RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Mario C. Gian, M.D., 610 Niagara St., Buffalo 1. Meetings second Monday, October to May.

CENTRAL NEW YORK ROENTGEN SOCIETY. *Secretary-Treasurer*, Dwight V. Needham, M.D., 608 E. Genesee St., Syracuse 10. Meetings in January, May, and October.

LONG ISLAND RADIOLOGICAL SOCIETY. *Secretary*, Marcus Wiener, M.D., 1430 48th St., Brooklyn 19. Meetings fourth Thursday evening, October to May, at 8:45 P.M., in Kings County Medical Bldg.

NEW YORK ROENTGEN SOCIETY. *Secretary*, Wm. Snow, M.D., 941 Park Ave., New York 28.

QUEENS ROENTGEN RAY SOCIETY. *Secretary*, Jacob E. Goldstein, M.D., 88-29 163rd St., Jamaica 3. Meets fourth Monday of each month.

ROCHESTER ROENTGEN-RAY SOCIETY. *Secretary*, Murray P. George, M.D., 260 Crittenden Blvd. Rochester 7. Meets at Strong Memorial Hospital, third Monday, September through May.

North Carolina

RADIOLOGICAL SOCIETY OF NORTH CAROLINA. *Secretary-Treasurer*, James E. Hemphill, M.D., Professional Bldg., Charlotte 2. Meets in May and October.

North Dakota

NORTH DAKOTA RADIOLOGICAL SOCIETY. *Secretary*, Charles Heilman, M.D., 1338 Second St., N., Fargo.

Ohio

OHIO STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Carroll Dundon, M.D., 2065 Adelbert Road, Cleveland 6. Next meeting at annual meeting of the State Medical Association.

CENTRAL OHIO RADIOLOGICAL SOCIETY. *Secretary*, Paul D. Meyer, M.D., Grant Hospital, Columbus. Meets second Thursday, October, December, February, April, and June, 6:30 P.M., Seneca Hotel, Columbus.

CINCINNATI RADIOLOGICAL SOCIETY. *Secretary*, Eugene L. Saenger, M.D., 735 Doctors Bldg., Cincinnati 2. Meets last Monday, September to May.

CLEVELAND RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, George L. Sackett, M.D., 10515 Carnegie Ave., Cleveland 6. Meetings at 6:30 P.M. on fourth Monday, October to April, inclusive.

Oklahoma

OKLAHOMA STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, W. E. Brown, M.D., 21st and Xanthus, Tulsa 4. Meets in October, January, and May.

Oregon

OREGON RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Boyd Isenhart, M.D., 214 Medical-Dental Bldg., Portland 5. Meets monthly, on the second Wednesday, at 8:00 P.M., in the library of the University of Oregon Medical School.

Pacific Northwest

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Sydney J. Hawley, M.D., 1320 Madison St., Seattle 4, Wash. Meets annually in May.

Pennsylvania

PENNSYLVANIA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, James M. Converse, M.D., 416 Pine St., Williamsport 8. Meets annually.

PHILADELPHIA ROENTGEN RAY SOCIETY. *Secretary*, Arthur Finkelstein, M.D., Graduate Hospital, Philadelphia. Meets first Thursday of each month at 8:00 P.M., from October to May in Thomson Hall, College of Physicians, 21 S. 22d St.

PITTSBURGH ROENTGEN SOCIETY. *Secretary-Treasurer*, R. P. Meader, M.D., 4002 Jenkins Arcade, Pittsburgh 22. Meets second Wednesday of each month at 6:30 P.M., October to June.

Rocky Mountain States

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Maurice D. Frazer, M.D., Lincoln Clinic, Lincoln, Nebr.

South Carolina

SOUTH CAROLINA X-RAY SOCIETY. *Secretary-Treasurer*, Robert B. Taft, M.D., 103 Rutledge Ave., Charleston 16.

Tennessee

MEMPHIS ROENTGEN CLUB. Meetings second Tuesday of each month at University Center.

TENNESSEE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, J. Marsh Frére, M.D., 707 Walnut St., Chattanooga. Meets annually with State Medical Society in April.

Texas

DALLAS-FORT WORTH ROENTGEN STUDY CLUB. *Secretary*, X. R. Hyde, M.D., Medical Arts Bldg., Fort Worth 2. Meetings on third Monday of each month in Dallas in the odd months and in Fort Worth in the even months.

HOUSTON X-RAY CLUB. *Secretary*, Curtis H. Burge, M.D., 3020 San Jacinto, Houston 4. Meetings fourth Monday of each month.

TEXAS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, R. P. O'Bannon, M.D., 650 Fifth Ave., Fort Worth 4. Next meeting Jan. 7–8, 1949.

Utah

UTAH STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, M. Lowry Allen, M.D., Judge Bldg., Salt Lake City 1. Meets third Wednesday, January, March, May, September, November.

Virginia

VIRGINIA RADIOLOGICAL SOCIETY. *Secretary*, P. B. Parsons, M.D., Norfolk General Hospital, Norfolk 7.

Washington

WASHINGTON STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Homer V. Hartzell, M.D., 310 Stimson Bldg., Seattle 1. Meetings fourth Monday October through May, at College Club, Seattle.

Wisconsin

MILWAUKEE ROENTGEN RAY SOCIETY. *Secretary-Treasurer*, Theodore J. Pfeffer, M.D., 839 N. Marshall St., Milwaukee 2. Meets monthly on second Monday at the University Club.

RADIOLOGICAL SECTION OF THE WISCONSIN STATE MEDICAL SOCIETY. *Secretary*, S. R. Beatty, M.D., 185 Hazel St., Oshkosh. Two-day meeting in May and one day with State Medical Society, September.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE. Meets first and third Thursdays 4 P.M., September to May, Service Memorial Institute, Madison 6.

Puerto Rico

ASOCIACIÓN PUERTORRIQUEÑA DE RADIOLOGÍA. *Secretary*, Jesús Rivera Otero, M.D., Box 3524, Santurce, Puerto Rico.

CANADA

CANADIAN ASSOCIATION OF RADIOLOGISTS. *Honorary Secretary-Treasurer*, E. M. Crawford, M.D., 2100 Marlowe Ave., Montreal 28, Quebec. Meetings in January and June.

LA SOCIÉTÉ CANADIENNE-FRANÇAISE D'ELECTROLOGIE ET DE RADIOLOGIE MÉDICALES. *General Secretary*, Origéne Dufresne, M.D., Institut du Radium, Montreal. Meets third Saturday each month.

CUBA

SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA DE CUBA. Offices in Hospital Mercedes, Havana. Meets monthly.

MEXICO

SOCIEDAD MEXICANA DE RADIOLOGÍA Y FISIOTERAPIA. *General Secretary*, Dr. Dionisio Pérez Conio, Marsella 11, México, D. F. Meetings first Monday of each month.

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ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Congenital Atresia of the Foramina of Luschka and Magendie, with Report of Two Cases of Surgical Cure. Claude C. Coleman and Charles E. Troland. J. Neurosurg. **5:** 84–88, January 1948.

Failure of development of the foramina of Luschka and Magendie is an interesting and important anomaly of the central nervous system. Very few instances of this anomaly have been recorded in the medical literature. To the 3 previously reported cases with surgical cure, the authors add 2.

The roentgenologic findings of the impression of the confluent and lateral sinuses on the parietal bone and a high inion are pathognomonic of atresia of the foramina of Luschka and Magendie. That this congenital anomaly can occur in the absence of these typical x-ray findings, however, is demonstrated by the 2 cases presented here. It is obvious that equilibrium must be established between the production of fluid in the ventricles and its escape into the subarachnoid system for this condition to be compatible with life. It is probable that, in the present cases, equilibrium was established early enough to permit posterior migration of the venous sinuses.

The balance in cerebrospinal fluid dynamics in cases exhibiting this congenital anomaly is a delicate one. The upsetting of the balance results in the precipitation of grave symptoms of increased intracranial pressure. In both of the authors' cases, the precipitating factor was trauma. The principal factors operating in the establishment of a balance are: (1) decreased production of fluid by the choroid plexuses, (2) dialysis of some fluid through the membrane forming the cyst wall, and (3) absorption of some fluid into the vessels of the cyst membrane, just as it is absorbed into the pial vessels in the subarachnoid system. It is possible that the atresia is not complete in all cases, although no semblance of an opening into the subarachnoid system could be found in either of the cases here reported.

Roentgenograms are reproduced.

Significance of the Widened Septum Pellucidum. Robert M. Lowman, Robert Shapiro, and Lois Cowan Collins. Am. J. Roentgenol. **59:** 177–196, February 1948.

Normally the septum pellucidum measures 0.2 to 0.3 cm. in width and 0.9 to 1.5 cm. in height (Davidoff and Dyke). Any increase in the above measurements is definitely abnormal and may be the result of one of numerous lesions. Widening of the septum pellucidum may be produced by (1) cysts of the cavum septi pellucidi, (2) tumors of the septum pellucidum, (3) agenesis of the corpus callosum, and (4) tumors of the corpus callosum. Other lesions which may offer problems in differential diagnosis are: (5) tumors of the third ventricle, (6) pinealomas, (7) tumors of the lateral ventricle, (8) mid-line frontal lobe tumors, (9) olfactory groove meningiomas, (10) parasagittal tumors, (11) thalamic tumors. These latter lesions (5–11) are fairly easily differentiated by other findings.

There are two types of cysts of the septum pellucidum and cavum vergae, communicating and non-communicating. The communicating cysts are usually well visualized by air studies and are the more common type. The non-communicating cyst is rare. Davidoff and Dyke found one such cyst in 5,000 encephalograms (Bull. Neurol. Inst. New York **4:** 602, 1936). Echternacht and Campbell, however, reported 3 examples in their paper on mid-line anomalies of the brain (Radiology **46:** 119, 1946). The larger number of cases reported by Echternacht and Campbell can probably be accounted for on the basis of a greater proportionate number of malformed children submitted for study and fewer adults. The non-communicating cyst is more prone to produce symptoms, such as convulsions, because of obstruction of the foramen of Monro and the resultant increased intracranial pressure. The cystic nature of the lesion, however, is not readily demonstrated in the air study. Non-communicating cysts may sometimes be differentiated from solid tumors by puncture of the septum pellucidum with an exploring trocar. This permits drainage of the cyst and filling with air. In addition, this procedure may be of some therapeutic value when further surgical intervention is not feasible.

Three cases of tumor of the septum pellucidum are presented. These are accompanied by reproductions of the air studies. The tumors were two fibrillary astrocytomas and one undifferentiated glioma of unspecified type. No reports of similar cases were found in the American literature by the authors.

Subdural Hematoma Outlined with Air in Encephalogram. Olle Olsson. Acta radiol. **29:** 95–99, Jan. 31, 1948.

Chronic subdural hematoma may be diagnosed by encephalography and ventriculography. Cerebral angiography may permit specific diagnosis by showing the cerebral vessels removed from the cranial wall at the site of a hematoma. Also a hematoma may be outlined with air in the subdural space.

The author presents the case of a 49-year-old farmer with a history of injury and the onset of symptoms two months later. Encephalography showed displacement of the septum pellucidum to the left. The right lateral ventricle was pushed under the falx toward the left. Subarachnoid air was present over the left hemisphere but none could be seen over the right hemisphere. There was moderate subtentorial air and, by changing the position of the head, it was possible to make the air on the right side move laterally. This formed a curved column about 12 cm. long and 5 mm. wide. The outer edge was clear cut, and lateral to it was a dense homogeneous area which was interpreted as a subdural hematoma on the right side. Operation confirmed the diagnosis. The author suggests that there is a good chance of obtaining enough subdural air if the gas is injected suboccipitally for encephalographic study.

JOHN R. HODGSON, M.D.

Upward Transtentorial Herniation of the Brain Stem and Cerebellum Due to Tumor of the Posterior Fossa, with Special Note on Tumors of the Acoustic Nerve. Arthur Ecker. J. Neurosurg. **5:** 51–61, January 1948.

Data from the literature and two illustrative cases indicate an upward herniation of the brain stem and cerebellum through the incisura tentorii in most cases of posterior fossa tumor. Such herniation might be called the inverted tentorial pressure cone or upward

transtentorial herniation. Identical ventriculograms may be obtained in cases of tumor of the cerebellum, pons, and floor of the third ventricle.

In acoustic nerve tumors, bulging and herniation through the tentorium may compress the inferior surface of the temporal lobe so as to obliterate the lumen of the temporal ventricular horn. Such herniation may also cause lateral compression of the lower portion of the third ventricle, simulating in the lateral ventriculogram a tumor of the third ventricle. Finally, it may elevate the first portion of the middle cerebral artery.

Upward herniation of cerebellum and brain stem causes double blockage of cerebrospinal fluid: both in downward flow at the aqueduct and in upward flow at the pontile and ambient cisterns. Furthermore, such herniation is likely to compress or distort the veins of Galen and Rosenthal, thus adding to the hydrocephalus, intracranial pressure, and congestion of the brain stem. Therefore, prolonged supratentorial ventricular drainage may be useless or harmful in some cases of tumor of the posterior fossa. Finally, it may be essential in many of these cases to section the tentorium at the notch in order to decompress the brain stem and the nearby veins.

On Changes of the Optic Canal in Cases of Intracranial Tumor. Arne Engeset and Arne Torkildsen. Acta radiol. **29:** 57–64, Jan. 31, 1948.

The authors review the literature dealing with the effect of intracranial lesions on the lower outer wall of the optic canal. This bony structure, which they call the "sphenoid strut," is of variable length and thickness and passes from the body of the sphenoid to its lesser wing. In spite of its variations, it is seen so constantly and so clearly in properly taken roentgenograms of the optic foramen that destructive changes, when present, are easily detected.

Four cases demonstrating destruction of the "sphenoid strut" are presented. In each instance the destruction was due to a neoplasm in or near the sella. In the experience of the authors, no other neoplasm produces this type of destruction. The only other pathological condition which might produce destruction of the lower outer rim of the optic canal is aneurysm of the internal carotid artery.

Increased intracranial pressure may produce thinning of the roof of the optic canal.

JOHN R. HODGSON, M.D.

Traumatic Intracranial Hemorrhage. E. S. Gurdjian and J. E. Webster. Am. J. Surg. **75:** 82–98, January 1948.

The authors have classified intracranial hemorrhagic collections resulting from injury in the following manner. (1) Epidural hemorrhage; (2) subdural hemorrhage: (*a*) acute type, (*b*) subacute chronic type, and (*c*) acute and chronic types in infants; (3) subarachnoid hemorrhage; (4) intraparenchymatous hemorrhage: (*a*) petechial and (*b*) massive; (5) subdural accumulation of spinal fluid.

Epidural hemorrhage most commonly occurs as a result of a tear of the middle meningeal artery or of the venous sinuses. Acute subdural hemorrhage usually results from a tear of pial vessels associated with contusion and laceration of cerebral tissue. Subacute and chronic subdural hematomas occur when the hemorrhage is so small as not to immediately jeopardize the brain within the cranial cavity. Osmosis and diffusion of cerebrospinal fluid and other tissue fluids into the collection of blood gradually cause the hematoma to expand. Additional volume is contributed by occasional hemorrhage into the clot from vessels in the proliferating granulation tissue on the dural side of the collection. Ultimately the expansion results in cerebral symptoms. Acute and chronic subdural hematoma in infants usually occurs as a result of birth injury, forceps injury, or fall. Subarachnoid hemorrhage is the most common variety of traumatic intracranial hemorrhage and it may coexist with epidural, subdural, and intraparenchymatous hemorrhage. It is usually brought about by lacerations and contusions of the brain surface. Subdural accumulation of spinal fluid may be caused by a rent in the arachnoid with a resulting valve-like action which permits cerebrospinal fluid to enter the subdural space and not return.

A similarity of symptoms and signs is shown to occur with these intracranial hemorrhagic collections. The state of consciousness and its alterations are significantly important. An increasing stupor and abolition of the conscious state after a lucid interval are indications for possible operative intervention. The neurologic status of the patient should be studied frequently. The progress of neurologic findings may be suggestive of an enlarging mass. If, on repeated examinations, the patient shows increasing weakness of one-half of the body, eventuating in paralysis, he may be afflicted with an enlarging blood clot. On the other hand, if a paresis or paralysis has been found to exist soon after injury, its causation by contusions and bruises of cerebral tissue is much more likely and therefore operative intervention may not be considered. The presence of inequality of pupils may be significant. The dilated pupil is usually on the side of the lesion and may occur as a result of compression of the oculomotor nerve by the enlarging clot. This compression may take place at the superior orbital fissure or along the course of the nerve from brain stem to cavernous sinus. Papilledema may be present, although this is rare. The vital functions may show alterations from normal. A slowing pulse rate and a lowered respiratory rate may accompany mass lesions. An increase in blood pressure, although unusual, may signify increasing intracranial tension.

In the presence of an acute hemorrhagic collection the single important symptom justifying exploration is increasing drowsiness or stupor. Pupillary inequalities, changes in vital functions, and focal neurologic signs may corroborate the presence of an enlarging clot. However, a dilated pupil, a low pulse rate, or hemiplegia in a perfectly conscious patient does not justify operative intervention.

In subacute and chronic subdural hematomas the presence of unilateral headache and hyperpathia of the scalp over the pathologic lesion are important. The association of severe brain injury with subdural hematoma produces long disability, and the recognition of a complicating subdural hematoma in long continued unconsciousness is important.

Post-traumatic epilepsy is rare in epidural and chronic subdural hematomas. In acute subdural hematomas it is seen in almost a third of the patients. This favors the assumption that in these patients the subdural hematoma is associated with contusions and bruises of the cerebral surface eventuating in cerebrodural cicatrization. Headaches, dizzy spells, and personality

changes are surprisingly uncommon as sequelae in postoperative mass lesions.

The article is well illustrated with excellent photographs of gross and microscopic specimens.

JOHN W. HOPE, M.D.

Diagnosis of Intracranial Aneurysms. James L. Poppen. Am. J. Surg. **75:** 178–186, January 1948.

Intracranial aneurysms are a frequent cause of sudden severe intracranial symptoms. The so-called cerebrovascular accident is due to a ruptured intracranial aneurysm much more frequently than has been suspected. Intracerebral hemorrhage is associated with ruptured aneurysm if the latter involves one of the branches of the middle, anterior, or posterior cerebral arteries. More commonly the hemorrhage is subarachnoid, since all of the larger branches, including the circle of Willis, lie in the subarachnoid space.

In the author's series of 114 intracranial aneurysms in 110 patients, the etiology presumably was related to congenital defects in the arterial wall. One exception was a patient with mycotic emboli. Hypertension was noted in 23 patients. In none was syphilis a factor.

The importance of early diagnosis, if possible before rupture, is emphasized, in view of the poor prognosis. Many of the recurrent hemorrhages take place within three weeks of the initial episode. Every attempt should therefore be made to establish the diagnosis and to localize the lesion with a view to determining whether or not it is amenable to some form of surgical treatment.

In the author's series, the initial symptom, other than that of subarachnoid hemorrhage, was in many instances bouts of unilateral headache and, in others, periodic attacks of generalized headache. Eighteen of the patients had no symptoms prior to actual rupture. Eighty-two had a history of previous subarachnoid hemorrhage. In 18 cases the symptoms were of gradual onset, usually caused by local pressure from a large aneurysm in the region of the sella turcica. In 12, the symptoms were initiated by generalized convulsions, and sudden hemiplegia occurred in 11 instances. Ophthalmoplegia is a common finding in patients with large aneurysms involving the internal carotid artery and in patients with extensive hemorrhage along the third cranial nerve. Diminished vision, sixth nerve palsy, papilledema, and optic pallor were among other findings. Large subclinoidal aneurysms result in involvement of the fifth cranial nerve. Involvement of the eighth to the twelfth nerves occurred in one patient with a large aneurysm of the basilar artery. The incidence of bruit in aneurysm is low.

The final diagnosis rests on either the arteriogram or direct surgical exploration. Plain stereoscopic roentgenograms may show changes in the bone caused by a large aneurysm in direct contact. Thinning of the lateral margin of the optic foramen has been described. Calcification may occur in an aneurysm and is manifested by a fine crescentic outline of dense calcification.

The author now utilizes arteriography in all patients suspected of aneurysm. Over 200 studies have been made with thorotrast and, more recently, with diodrast, with no untoward effect. Recent subarachnoid hemorrhage is not considered a contraindication to the procedure. The closed, indirect method of injection is usually employed, except when visualization of the vertebral arterial system is required. The arteriograms are frequently made immediately following encephalography, with the patient still asleep from pentothal. The author is convinced that the combined method should be used much more frequently.

The upright automatic Bucky suitable for stereoscopic exposures in chest work is utilized. The first exposure is made during the rapid injection of 15 c.c. of the 20 c.c. of diodrast (30 per cent). The injection is continued during the automatic shifting of the tube and second exposure. This allows adequate filling for stereoscopic films, and these are considered to be more satisfactory than a single lateral and an anteroposterior view.

DAVID S. MALEN, M.D.

Chronic Mastoiditis and Its Roentgen Picture. Marcus Diamant and Bengt Lilja. Acta radiol. **29:** 37–56, Jan. 31, 1948.

Previous investigation of the mastoid cell system has revealed that cell systems of various sizes occur normally, that the smaller ones easily become the site of chronic otitis and also that they are more frequently involved by acute otitis.

The authors consider chronic mastoiditis a permanent indolent infection in the cell system which is often followed by productive osteitic changes with osseous accretions on the cell walls that are demonstrable on roentgen examination.

Nine cases are presented in which the roentgen findings and pathological reports are correlated. In 3 cases cholesteatoma was present but was not demonstrated roentgenologically, presumably because "one has reached the limits of the possibilities afforded by the roentgenological method." The characteristic roentgen features of the nine cases are "thick bony trabeculae which roughen toward the cell lumen and generally enclose small dispersed cells and in some cases partial destructions."

New bone formation in the cell walls may occur relatively early in the course of acute mastoiditis and new bone formation in the form of accretions was demonstrated histologically in four cases.

The authors emphasize that, although the clinical picture may be varied and uncertain, the roentgenologic diagnosis of chronic mastoiditis is relatively easy in typical cases.

JOHN R. HODGSON, M.D.

Malignant Tumors of the Nasopharynx. Thomas E. Van Metre, Jr. Bull. Johns Hopkins Hosp. **82:** 42–55, January 1948.

Forty-six cases of malignant tumor of the nasopharynx studied at the Johns Hopkins Hospital between 1925 and 1946 are analyzed. In all of these cases, a growth could be seen in the nasopharynx. Twenty-six of the biopsied tumors were epithelial and 7 mesothelial. In 33 cases, the clinical findings seemed sufficient to establish the diagnosis even without microscopic proof. The highest incidence of tumor was in the fifth and sixth decades. Sixty-three per cent of the patients were males.

Roentgenograms of the skull were obtained in only 21 of the 46 cases; in 7 there was no evidence of tumor. In 12 cases definite erosion of the base of the skull was visible. There was evidence of a soft-tissue mass displacing the nasopharyngeal air column in 7 instances. Had anteroposterior and lateral views of the skull and stereoscopic films of the base of the skull been

taken routinely, they probably would have revealed signs of tumor in a large percentage of the cases.

An attempt is made to explain the clinical picture in nasopharyngeal tumor on the basis of the anatomy of the nasopharynx, the properties of neoplastic growth, and the disturbances created by pressure, obstruction, and destruction.

THE CHEST

Bronchiectasis. Jacob Jesse Singer. Dis. of Chest **14:** 92–106, January–February 1948.

The use of iodized oil has greatly facilitated the study of bronchiectasis. The disease is now readily differentiated from pneumonia, tuberculosis, cancer, fungus infections, abscess, and the numerous fibroses, with which it was formerly often confused.

Congenital bronchiectasis develops in fetal life by fibrosing bands and cysts and failure of expansion of the alveoli. Acquired bronchiectasis usually follows pneumonia associated with measles or whooping cough or any condition producing an atelectasis of an area supplied by a small or large bronchus, as foreign bodies, bronchial tumor, lung abscess or lung cyst, tuberculosis, deformity of the chest wall, compression of the lung by hydrothorax, allergic bronchitis, silicosis, and lipid pneumonia.

Various types of bronchiectasis.

Cylindrical enlargement of the bronchi with atelectasis of the surrounding lung tissue is the usual type of involvement in congenital bronchiectasis. Evidences of inflammatory change are either absent or slight. Multiple irregular cysts may be present in one or more lobes. In the acquired form the infection may begin in the mucosa, involve the bronchus, ending with ulcerations, strictures, and dilatations. A transitory bronchiectasis has been described in association with atypical pneumonia (Blades: J. Thoracic Surg. **13:** 40, 1944. Abst. in Radiology **43:** 404, 1944).

The author describes the clinical symptoms, physical signs, and methods of diagnosis and treatment. He includes a schematic drawing of the various types of bronchiectasis. HENRY K. TAYLOR, M.D.

Pneumonias Associated with Epidemic Respiratory Infections. J. G. Scadding. Lancet **1:** 89–93, Jan. 17, 1948.

Apart from the rickettsial and psittacosis types of pneumonia, the outbreaks described as primary atypical pneumonia vary from mild epidemic upper respiratory catarrh, in a small proportion of which transient pulmonary consolidations have been discovered radiologically, to more severe respiratory infections with pulmonary consolidations in a high proportion of cases and a febrile illness of several weeks duration with some mortality. There has also been a tendency to describe any pneumonia whose etiology is not precisely understood as primary atypical pneumonia.

Though some published roentgenograms show lesions of a diffuse non-segmental distribution or in small foci, in many there are segmental shadows which might be interpreted as aspiration pneumonias. Some workers have recognized the roentgenologic resemblance to atelectasis, but lateral views seem rarely to have been taken. Attempts to isolate a virus in primary atypical pneumonia, excluding psittacosis and rickettsiasis, have met with little success.

The author believes that the term "primary atypical pneumonia" should be abandoned. When the evidence suggests infection by an unidentified virus, the case should be called "pneumonia, presumably due to an unidentified virus." When the findings suggest a nonspecific infected atelectasis complicating an acute or chronic, infective or non-infective respiratory catarrh, the labels "infected atelectasis" or "aspiration pneumonia" should be applied.

Q-Fever (Queensland Fever) in Switzerland (Endemic Pneumonia Due to Rickettsia burneti). Otto Gsell. Schweiz. med. Wchnschr. **78:** 1–8, Jan. 10, 1948.

In the early part of 1947 serologically proved Q-fever appeared in Switzerland. The cases fell into four groups. The first was a family epidemic of 7 cases, 4 of them starting within three days with sudden onset of high fever, lasting six to nine days, severe headache, relative bradycardia, and a normal white blood cell count with a shift to the left in the differential. The second group was a town-wide epidemic of about 50 cases affecting chiefly growing young men, with one fatality. The third group consisted of a number of sporadic cases near St. Gall and Gossau, and the fourth group consisted of about 30 epidemic cases in Genf.

The most common clinical symptom was a sudden high fever, with anorexia, malaise, and later in the course vomiting, sweats, severe headache, or even stupor. Physical examination was usually negative. Chest roentgenography, the most useful diagnostic procedure, showed unexpected extensive infiltrations in the form of multiple soft densities. In the later stages of the more severe cases, the pneumonia sometimes led to detectable physical signs. The course was almost always benign, the fever dropping after five to twelve days. Serous pleurisy, orchitis, and thrombophlebitis were the only complications. The routine agglutination tests, the Wassermann reaction, and cold agglutination tests were negative, and the scanty sputum showed no pneumococci. All sera showed a positive complement-fixation titer for *Rickettsia burneti*. Blood inoculation into guinea-pigs was positive on the first two passages for specific antibodies of *Rickettsia burneti*. Clinically and serologically the occurrence of these outbreaks of Q-fever and rickettsial pneumonia has thus been proved.

LEWIS G. JACOBS, M.D.

Pneumonic Complications Following Accidental Aspiration of Naphtha: Clinical and Experimental Study. Mariano R. Castex, Egidio S. Mazzei, Mario S. Dreyer, and Eduardo Abel Pedace. Prensa méd. argent. **35:** 3–20, Jan. 2, 1948.

The pathology of pneumonic lesions following the aspiration of naphtha and similar substances is based on the passage of the toxic material into the respiratory passages either directly or in connection with vomiting. Passing along the trachea or bronchi, the liquid reaches

the pulmonary alveolar structures, where it provokes intense irritation, with consequent infiltration and atelectasis. There soon develops a pneumopathy characterized by cough, increasing dyspnea, intense pain, and respiratory grunts. The physical symptoms include cyanosis, flushing, which simulates a rash, diminished expansion, dyspnea, and bloody frothy sputum, which later becomes mucopurulent. The right lung is most often the seat of the lesion. Atelectasis of the lower lobe and infiltration and pneumonic consolidation of the middle lobe are the usual findings. Radiologically the changes are evident at the eighth to tenth hour or earlier. The authors' case was followed periodically until complete cure of the pulmonary parenchyma was demonstrated.

Treatment consists in restoratives, morphine for pain, and penicillin to prevent infection, which may follow the first phase of aseptic irritation. The prognosis generally is favorable. When death occurs, it is early, during the stage of vomiting, somnolence, and generalized toxemia. JAMES T. CASE, M.D.

Early Pleural Effusion in Pulmonary Embolism and Pneumonia or Bronchopneumonia. Gunnar Moberg. Acta radiol. 29: 7–18, Jan. 31, 1948.

Recent investigation has shown that there are no characteristic parenchymal and vascular changes in the roentgenogram of the lungs in cases of pulmonary embolism. Because of the frequent association of pleural changes and pulmonary embolism, the author investigated 46 cases of the latter condition and 170 cases of pneumonia and bronchopneumonia in an effort to ascertain the differential diagnostic value of pleural effusion. A comparison study of the cases of pneumonia and bronchopneumonia was also done but it is pointed out that of the 170 cases only 38 were submitted to roentgen examination within six days of the initial symptoms. Roentgen examinations in the cases of embolism were done within three days of the appearance of symptoms.

The author had believed that the presence of fluid in the pleural cavity at an early stage without parenchymal densities, or with very small ones, was typical of pulmonary embolism, whereas in early pneumonia the pleural effusion was insignificant compared to the parenchymal consolidation. The present study did not bear this out.

Of the 46 cases of pulmonary embolism, 21 were found to have pleural effusion and small or no areas of parenchymal consolidation. In 4 cases the effusion and parenchymal density were about equally prominent and in 2 cases the relation was uncertain. In 19 cases the parenchymal density was greater than the pleural effusion. In the 38 cases of pneumonia and bronchopneumonia the density in the lung parenchyma was the predominant feature in 33 cases. Densities in the parenchyma and pleura were about equally dominant in 3 cases and pleural effusion was the most pronounced finding in 2 cases.

It can be said that early pleural effusion either without or with only small parenchymal densities is common in postoperative pulmonary embolism but less common in pneumonia and bronchopneumonia. Relatively large parenchymal densities without demonstrable pleural effusion or with slight pleural effusion occur, however, fairly frequently in pulmonary embolism. The author concludes that we need a better method for the differential diagnosis of pulmonary embolism and pneumonia and bronchopneumonia.

The paper is illustrated with a number of roentgenograms demonstrating pulmonary embolism and bronchopneumonia. JOHN R. HODGSON, M.D.

Cystic Disease of the Lung with Report of a Case. Peter A. Theodos. Dis. of Chest 14: 115–120, January–February 1948.

A woman aged 35 first complained of persistent dyspnea in the summer of 1940. During an attack of "grippe" in the following December, physical examination revealed absence of breath sounds on the right side and x-ray examination showed what appeared to be a spontaneous pneumothorax on that side. After three months of bed rest the lung had not re-expanded, and dyspnea was more severe. The patient was examined fluoroscopically in April 1941, and a diagnosis of tension pneumothorax with a check-valve fistula was made. However, no improvement followed frequently repeated deflations of 2,000 to 3,000 c.c. of air over a period of two months. In May a thoracoscopy was done, and what had been taken for adhesions in the x-ray study was found actually to be the base of a giant cyst filling the entire pleural cavity. The cyst communicated with a bronchus in the apex of the right upper lobe. Following surgery, the right lung re-expanded and the dyspnea was relieved.

The term cystic disease has been applied to a wide variety of abnormal localized distentions of parts of the bronchial tree and pulmonary parenchyma. Such distentions may be divided into two groups depending upon the absence or presence of an epithelial lining. Cysts with no epithelial lining have a wall of connective tissue containing no bronchial elements. In those with an epithelial lining the wall may contain cartilage, glands, and smooth muscle fibers of bronchial origin, in which case a congenital origin may be assumed; if bronchial elements are absent, the condition is considered to be acquired. The cysts may be small or large, single or multiple. The diagnosis depends mainly upon x-ray study, including bronchography, and requires differentiation from spontaneous pneumothorax, emphysematous blebs, abscess cavities, cystic bronchiectasis, and thin-walled cavities of other origin.

HENRY K. TAYLOR, M.D.

Cervical Herniation of the Lung. J. F. Meakins, C. J. Wyatt, and M. Aronovitch. Canad. M. A. J. 58: 33–35, January 1948.

Two cases of cervical herniation of the apex of the lung are reported. This is a rare condition, of which approximately 200 cases appear in the literature. According to Maurer and Blades (J. Thoracic Surg. 15: 77, 1946), whom the authors quote, these hernias usually occur through the superior aperture of the thorax into the anterior triangle of the neck, the herniated lung tissue lying between the sternocleidomastoid and the scalenus anticus muscles. They are most commonly congenital. The defect is usually associated with a cervical mass above the level of the clavicles which is soft, elastic, sometimes crepitant, and easily reducible. The two cases reported here are believed to be unique in that their onset was definitely related to trauma. In each case the clinical diagnosis was confirmed radiologically. The report on the film in the first case read: "soft tissue swelling on the right side of the neck which is of very light density, extending up to the level of the fifth cervical vertebra." This

patient died with multiple cancer and the presence of the pulmonary hernia was further established at autopsy.

JOHN DECARLO, M.D.

Hemosiderosis of the Lungs—Typical Roentgenological Findings. Olle Elgenmark and Sven Roland Kjellberg. Acta radiol. **29:** 32–36, Jan. 31, 1948.

The authors present a case of hemosiderosis of the lungs which had been observed over a two-year period. The signs and symptoms are cyanosis, dyspnea, and cough, which usually appear soon after birth or during the first few years of life. The sputum may be blood-tinged, and staining with 2 per cent potassium ferrocyanide reveals the presence of hemosiderin pigment. The disease is characterized by an anemia of the secondary type, eosinophilia of 5 to 10 per cent and in some cases moderate leukopenia. Temperature and sedimentation rate are usually slightly elevated.

The roentgen characteristics are diffuse shadows of increased density scattered over both pulmonary fields and independent of the borders of the lobes. This cloudiness of the pulmonary parenchyma alternates with mottling of a mossy appearance. In the early stages and at the time of the remissions the mottling is the dominant feature. The hilar shadows are enlarged. The areas of increased density and the mottled appearance are caused by the filling of the alveoli with iron pigment.

The disease occurs more frequently in females; the treatment is symptomatic and the prognosis is poor. All patients with the disease eventually die from it.

JOHN R. HODGSON, M.D.

Follow-up Diagnosis on Patients with X-ray Lesions, with Special Emphasis on Tuberculosis. William Roemmich. Minnesota Med. **31:** 29–36, January 1948.

Early in his paper the author makes the point that everything that looks like tuberculosis roentgenologically is not tuberculosis clinically. The diagnosis of tuberculosis from a film alone he considers inexcusable. His position is made clear in the following statement: "The x-ray is an economical tool in tuberculosis case finding . . . it remains as one of the objective and valuable diagnostic aids. My discussion of its use in the differential diagnosis of tuberculosis is not intended to discredit x-ray but to urge an even wider application with a more extensive use of complementary diagnostic aids." Of these latter, he discusses three: bacteriologic studies; the tuberculin test; history and physical examination. Particular stress is laid on the importance of repeated sputum examinations.

All phases of the discussion reflect abundant experience on the part of the author (who is the Acting Tuberculosis Control Officer of the Minneapolis City Health Department) and are tempered with that most valuable quality in practice—common sense. Much art and skill are required to determine the status of certain patients who have received a roentgenologist's report of a pulmonary lesion suggesting active tuberculosis. Much harm may be done sociologically and economically by the dislocation of such persons from their ordinary places in life if it is done needlessly. The problem is to discover who has active tuberculosis—the sort in which specialized treatment is imperative. The giving of such treatment where it is not needed can work endless harm to those concerned.

Anyone interested in mass surveys, and particularly anyone who thinks the mass survey begins and ends with an x-ray film, is referred to this article for thoughtful and careful study.

PERCY J. DELANO, M.D.

Mass Chest Survey at the University of Kansas Medical Center Out Patient Dispensary. Joseph W. Burnett and G. M. Tice. J. Kansas M. Soc. **49:** 19–22, January 1948.

Another photofluorographic chest survey is reported, covering 5,218 clinic patients and extending over a period of one year. Of those examined 4,491 were followed; 229 showed chest lesions and, on subsequent study with 14 × 15 inch films, 53 were found to have tuberculosis—14 moderately or far-advanced disease and 39 minimal lesions. Many significant abnormal non-tuberculous chest findings were recorded, a large percentage of which were previously unsuspected.

"Over-reading" of the miniature films was of common occurrence, but was considerably reduced with experience.

Occupational Beryllium Poisoning in New Jersey (with Special Reference to Its Incidence, Diagnosis and Compensation). Harrison S. Martland, Henry A. Brodkin, and Harrison S. Martland, Jr. J. M. Soc. New Jersey **45:** 5–14, January 1948.

As the result of widespread use of beryllium in the manufacture of precision instruments, machines, alloys, phosphors, electric filaments, and ceramics, a new industrial disease has become evident with acute and chronic pulmonary manifestations. The acute forms of the disease occur in the beryllium extraction industries, where workers are exposed to high concentrations of the fumes and dusts of the sulfates, fluorides, and oxyfluoride salts. The chronic forms are seen chiefly in the fluorescent lamp industry, entailing exposure to phosphor powders containing zinc beryllium silicate.

The acute form of the disease shows a rapid course, with either complete recovery or death. The symptoms, which are those of an upper respiratory infection, are progressive and eventually require bed rest and oxygen to overcome exertional dyspnea and cyanosis. The chronic form is insidious in its onset, with symptoms appearing, as a rule, one and one-half years after exposure. The early symtoms are anorexia, weight loss, dyspnea, cough, weakness, and cachexia. Symptoms are progressive as pulmonary fibrosis supervenes, leading to pulmonary hypertension, cor pulmonale, and clubbed fingers. Hepatomegaly and splenomegaly develop, and eventually the patient succumbs to cardiorespiratory failure.

In the acute phase, the chest films are negative for the first few weeks, followed by diffuse haziness of the lung fields in all instances. Irregular areas of infiltration with increased bronchovascular markings succeed these findings, and in turn, are followed by the appearance of discrete, small or large conglomerate nodules. Clearing occurs before clinical signs and symptoms disappear. Residual fibrosis may persist.

In the chronic form, three stages are described. The stage of granularity is the most distinctive phase. Small, finely particulate granulations are seen diffusely scattered throughout the lung fields. These have the appearance of fine sandpaper and when seen under a magnifying lens resemble a "sandstorm." A reticular pattern is superimposed on the granular background in

the second stage, or stage of reticulation. There may be slight fuzziness and enlargement of the hilar areas. The stage of nodularity is characterized by discrete nodules, measuring up to 5 mm., which do not calcify, cavitate, or coalesce. The appearance is reminiscent of a snowstorm. The hilar areas become more fuzzy and prominent. Cor pulmonale and right-sided cardiac failure may occur in this stage.

The roentgenologic stage does not necessarily correspond to the clinical picture. The patient may be more severely ill in the stage of granulation than in the nodulation stage. The degree of cor pulmonale and right heart enlargement is a good index as to the severity of the disease. Emphysema is occasionally noted, and pneumothorax rarely.

LOUIS BERNSTEIN, M.D.

Roentgenologic Pulmonary Manifestations of Fatal Histoplasmosis. John F. Holt. Am. J. Roentgenol. **58:** 717–723, December 1947.

Five cases of fatal histoplasmosis with pulmonary involvement are reported. Only one of these cases has not been previously reported but the histories are repeated here in summary and chest roentgenograms are presented. Analysis of the findings in the five cases indicates that the pulmonary changes are fully as varied as the clinical manifestations of the disease. None of the roentgen findings is typical, and the roentgenologist must be satisfied to point out the presence of an abnormality and suggest the possible diagnosis. The possibility of *Histoplasma* as an etiological agent of chronic pneumonitis should be mentioned where widespread, coarse, granular parenchymal lesions are encountered. The final diagnosis is dependent upon the demonstration of the organism by laboratory methods.

G. K. VOLLMAR, M.D.

Pulmonary Radiologic Manifestations of a Histiocyto-eosinophilic Granuloma of the Lower Jaw and of the Skull. R. Gilbert and G. Voluter. J. de radiol. et d'électrol. **28:** 465–467, 1947.

The pulmonary manifestations of a case of eosinophilic granuloma are described in detail. The patient was a 20-year-old female presenting osteolytic lesions in the skull and right mandible and multiple miliary nodules in both lungs. There was a right spontaneous pneumothorax with collapse of about one-third of the right lung, which was attributed to rupture of one of the subpleural granulomata.

The authors propose to name the syndrome "histiocyto-eosinophilic granulomatosis of the lung."

RODERICK L. TONDREAU, M.D.

The Disease Picture and Differential Diagnosis of Bronchial Adenoma. A. Kappert. Schweiz. med. Wchnschr. **78:** 26–31, Jan. 17, 1948.

Adenoma is the most common benign bronchial tumor, constituting about 75 per cent of such growths. Unlike carcinoma, it is more frequent in women, occuring generally in the second or third decade. The course is characteristic, and can be divided into three phases. The first, lasting years or decades, is the period of purely intrabronchial growth. During this stage the most frequent symptom is hemoptysis, although this may consist only in slight flecking of the sputum with blood. The bleeding occurs irregularly, except that in women it may often recur in the menstrual or premenstrual period. Less common are cough, thick sputum, and slight dyspnea most marked on exertion. When the bronchial lumen is very narrow, a wheeze or whistle, best heard with the patient's mouth open, makes its appearance. On auscultation a partial stenosis is suggested by rough breath sounds distal to the tumor. At this stage most laboratory and x-ray studies are normal. Because of the bleeding, a diagnosis of tuberculosis is commonly made.

The second phase is that of bronchostenosis with atelectasis. Ball-valve emphysema is only rarely seen at this stage. Inflammatory changes take place, and pleural complications are common, making the differential diagnosis from unresolved pneumonia and pleuropneumonia difficult. The pleural complications may consist in either dry pleurisy over the diseased area, or of exudative pleurisy. Interlobar effusion is not infrequently confused with atelectasis of a lobe.

The third phase is characterized by development of severe complications behind the block, such as abscess, gangrene, or bronchiectasis, and these, if untreated, may lead to death.

Diagnosis is by bronchoscopy with biopsy. All other procedures, even bronchography with or without tomography, may give negative results in the first stage and be inconclusive even in the later stages, when the diagnosis is less difficult. In the differential diagnosis one must consider the inflammatory reaction about foreign bodies, especially in children; bronchostenosis due to enlarged lymph nodes, either tuberculous or nonspecific; tuberculous bronchitis; malignant neoplasm; endogenous foreign bodies (such as pseudomembranes, sequestrated cartilage, etc.); and non-specific inflammatory pseudotumors of the mucosa. In the third stage differentiation from lung abscess and from empyema is often difficult. While the bronchial stenosis is often demonstrated by bronchography, biopsy is the only conclusive proof of the condition. Laboratory demonstration of tumor cells in the sputum has not been found possible.

Prognosis is related directly to diagnosis and treatment. Most deaths result from the complications of the third stage. A rarity is death from hemorrhage in the first stage. Malignant change has never been conclusively demonstrated. Occasional reports of metastases are thought to be due to confusion of atypical carcinomas with this tumor. The original treatment by endobronchial removal has not proved satisfactory, and lobectomy or pneumonectomy is now recommended as the procedure of choice.

Several illustrative cases are reported, with excellent reproductions of the roentgenograms.

LEWIS G. JACOBS, M.D.

Phalangeal Metastases in Bronchogenic Carcinoma. Report of Three Cases. G. M. Colson and A. Willcox. Lancet **1:** 100–102, Jan. 17, 1948.

Three cases of bronchogenic carcinoma are reported in which there occurred phalangeal metastases clinically closely resembling an inflammation. In two cases the lesions were initially assumed to be due to a paronychia or whitlow, and in the third to an infected bunion. The relative mildness of the pain raised doubt of the diagnosis in one instance, until radiography showed the real nature of the lesion. The roentgen findings were essentially similar in all 3 cases. In 2, aspiration biopsy proved helpful.

Mechanisms Underlying Pulmonary and Cardiac Complications of Electrically Induced Convulsions. M. D. Altschule and K. J. Tillotson. New England J. Med. **238:** 113–115, Jan. 22, 1948.

Induced convulsions are at times followed by atelectasis and lung abscess. The convulsion is ushered in by a maximal forced expiration which is represented on the roentgenogram by elevation of the diaphragm and narrowing of the intercostal spaces. At the end of the convulsion, relaxation occurs and re-expansion of the lung follows. At this time secretions may be introduced into the pulmonary passages, and atelectasis or lung abscess may develop. Exacerbation of latent tuberculosis has also been known to follow this type of therapy.

Because of the increased thoracic pressure during a convulsion, the coronary arteries are protected from injury. This same increased intrathoracic pressure prevents abnormal venous return to the heart, resulting in a smaller heart with less work to do. After the termination of the convulsion the cardiac work is increased, due to discharge of accumulated oxygen debt. This increased work has been known to result in myocardial infarction following the convulsion.

A case is reported in which lung abscess followed an induced convulsion; also one in which angina pectoris with electrocardiographic changes developed.

JOHN B. MCANENY, M.D.

Mediastinal Hernia. P. Eichler. Schweiz. med. Wchnschr. **78:** 67–68, Jan. 24, 1948.

The mediastinum serves three functions; (1) as a wall between the two halves of the thorax; (2) as a passageway for the vital structures; and (3) as a collecting station for lymph. Diseases of the mediastinum may accordingly be classified by the function which they injure. Mediastinal herniations or displacements fall into the first group; space-occupying lesions, which secondarily compress the vital structures, into the second; inflammatory processes, hemorrhage, and mediastinal emphysema into the third.

The anatomy of the mediastinum results in two weak points: the site of the thymus, which is filled largely with fatty and areolar tissue and has only thin walls, and the posterior caudal part of the chest between the vertebral column and the heart. A pressure differential may produce a hernia in either of these. A case of hernia of the first, secondary to a therapeutic pneumothorax on the left (for fibrocaseous tuberculosis), is described. The identity of the hernial pouch was proved by instillation of lipiodol into the left thorax followed by radiographic study. LEWIS G. JACOBS, M.D.

Study of the Radiographic Anatomy of the Normal Thymus by Means of a Pneumomediastinum. Goffredo Giannardi. Radiol. med. (Milan) **34:** 27–41, January 1948.

The author has studied 11 adult cadavers with lateral roentgenograms of the chest following the injection of air in the anterior mediastinum. He concludes that after the introduction of air, the normal thymus does not cast a shadow definite enough for accurate study.

CESARE GIANTURCO, M.D.

Angiocardiography: Its Use in the Diagnosis of Patent Ductus Arteriosus. Robert A. Furman. New England J. Med. **238:** 116–120, Jan. 22, 1948.

The author presents a case of patent ductus arteriosus diagnosed by angiocardiography with diodrast. The patient was tested for sensitivity and the history was carefully investigated for personal or familial allergy or sensitivity. The standard phenolsulfonephthalein urinary excretion test was done to rule out delayed kidney excretion. There was no clinical evidence of hyperthyroidism or hepatic disease. Fifty cubic centimeters of diodrast was injected into a vein of the arm within two seconds, through a 13-gauge transfusion needle. The rapid exposure of films was done by the manual passage of six consecutive films within ten seconds accomplished by two assistants.

Nothing new is added to the subject of patent ductus arteriosus, but the report shows what can be done with care and ingenuity in a small rural hospital.

JOHN B. MCANENY, M.D.

Differentiation of Patent Ductus Arteriosus and Atrial Septal Defect. A. D. Nichol and Don D. Brannan. Am. J. Roentgenol. **58:** 697–707, December 1947.

Patent ductus arteriosus and atrial septal defects present sufficiently characteristic findings to make possible a correct diagnosis in a large percentage of cases. A table is presented listing the various differential points. Patent ductus arteriosus is characterized by enlargement of the left ventricle and left auricle, large pulmonary arteries, and a large aorta, in contradistinction to atrial septal defect, which shows enlargement of the right auricle and right ventricle, great dilatation of the pulmonary artery, and a rather small aorta. In patent ductus arteriosus the electrocardiogram is normal or shows slight left axis deviation, whereas in atrial septal defect there is almost always right axis deviation associated with large P waves and various arrhythmias. In patent ductus arteriosus there is usually a high systolic and low diastolic blood pressure resulting in a rather high pulse pressure. In atrial septal defect the systolic blood pressure is low with a narrow pulse pressure. Numerous other differential points are discussed and illustrated. Case reports, roentgenograms and electrocardiograms are included. There is also a good discussion of the pathology and pathologic physiology involved in the two congenital defects. G. K. VOLLMAR, M.D.

Syndrome of Aberrant Right Subclavian Artery with Patent Ductus Arteriosus. Henry P. Brean and Edward B. D. Neuhauser. Am. J. Roentgenol. **58:** 708–716, December 1947.

Fifteen cases of right anomalous subclavian artery are reported. In 5 of these there was associated congenital heart disease (patent ductus arteriosus in 3, tetralogy of Fallot in 1, and a congenital abnormality of undetermined structure, apparently involving an intracardiac shunt, in 1). These 5 cases are reported in rather full detail. The authors discuss the embryological factors involved in production of the anomalous subclavian artery, and suggest that the frequent association with other congenital heart defects indicates a common etiological agent.

The roentgenologic features of the anomalous right subclavian artery and of patent ductus arteriosus are reviewed and several excellent illustrations are furnished. The value of a routine barium swallow to demonstrate the typical oblique extrinsic filling defect in the posterior esophageal wall is emphasized.

G. K. VOLLMAR, M.D.

THE DIGESTIVE SYSTEM

Movements of the Esophagus in the Presence of Cardiospasm and Other Esophageal Diseases. A Roentgenologic Study of Muscular Action. Frederic E. Templeton. Gastroenterology **10:** 96–101, January 1948.

The physiology of the normal esophagus is reviewed and evidence is presented that a more or less characteristic pattern of muscular action occurs in achalasia (cardiospasm). In 36 of 39 patients studied by fluoroscopy and esophagoscopy, the primary peristaltic wave was seen to cease at about the level of the suprasternal notch instead of proceeding through the entire length of the esophagus as it does normally. The portion of the esophagus over which the wave passed remained contracted for a second or two and, when it relaxed, the content flowed upward and was prevented from entering the pharynx by the contracted cricopharyngeus muscle; no secondary waves were observed. In all but two cases, purposeless, shallow, segmental contractions appeared and disappeared at different levels of the esophagus. They were ineffective in moving the bolus. Generalized tonic contractions accompanied the undulating movements and in the presence of a contracted cricopharyngeus some of the barium mixture was forced into the stomach.

Amyl nitrite caused all esophageal muscular action to cease in the supine patient. The cardia relaxed in erect patients.

Studies were also made in cases of carcinoma, chronic esophagitis with stricture, and stricture of unknown origin. In all but one of the patients having carcinoma, benign stricture, or esophagitis, the primary wave progressed down to the lesions involving the lower endof the esophagus or skipped over the lesions higher up.

In 4 cases of bulbar palsy a deep peristaltic wave began at or slightly below the cricopharyngeus and progressed to the stomach. Pharyngeal muscles contracted inadequately.

In generalized scleroderma, muscular action was similar to that seen in achalasia, except that in the standing position there was no delay in passage through the cardia. In 5 of the 6 patients in this group the primary wave faded out entirely at the suprasternal notch level and no local or tonic contractions were seen below.

In tabes dorsalis no muscular action occurred in the esophagus. In the erect position barium passed readily into the stomach.

Etiologic theories of cardiospasm are discussed and it is concluded that cardiospasm is a disease of the smooth, muscular portion of the esophagus, and not of the lower end, that this disease in some manner destroys the propagating mechanism of the peristaltic wave, and that in the advanced state there is associated a marked loss of tone and dilatation.

ALTON S. HANSEN, M.D.

Pyloric Obstruction and Stricture of the Esophagus Following Ingestion of Lye (Sodium Hydroxide Mixed with Sodium Carbonate). Donald S. Bolstad. Arch. Otolaryng. **47:** 180–184, February 1948.

Only one case of pyloric obstruction associated with stricture following ingestion of lye has been found recorded in the American literature (Vinson and Hartman: M. Clin. North America **8:** 1037, 1925). The author reports two more. Both patients were women who ingested lye with suicidal intent. In each instance, the pyloric obstruction, apparently complete, occurred within a relatively short period. Gastroenterostomy, the procedure of choice for such pyloric obstruction, was done in both cases, controlling the symptoms of obstruction satisfactorily. Esophageal dilatations were also necessary in both. Roentgenograms are reproduced.

Superficial Spreading Carcinoma of the Stomach. Ross Golden and Arthur Purdy Stout. Am. J. Roentgenol. **59:** 157–167, February 1948.

Superficial spreading gastric carcinoma arises in the mucous membrane of the stomach and may remain and grow in the mucosa and submucosa for some time before further invasive characteristics develop. Theoretically this type of lesion is curable if its detection and removal can be accomplished before invasion or metastasis occurs. While the lesion is not encountered frequently, its importance is immediately realized when one considers its theoretical curability.

Superficial spreading carcinoma of the stomach was first detected in the Department of Surgical Pathology of the Presbyterian Hospital, New York City, in 1937, and the authors have now seen 31 cases, comprising 14 per cent of all carcinomas of the stomach treated. Metastases to regional lymph nodes were encountered in 15 of the 31 patients. Thirty lesions developed in the lower half of the stomach; in one instance the cardiac orifice was the primary site, with involvement of the gastric fundus. An open ulcer was present in 26 of the 31 cases, and cancer developed around an open ulcer in 12 instances. Gastroscopic evidence consistent with or suggestive of cancer was found in 9 of 11 patients in whom gastroscopy was done.

Twenty-nine of the 31 patients had roentgen examinations at the Presbyterian Hospital. In 20 of 24 patients with ulcerating cancer or peptic ulcer with cancer, proved histologically, an ulcer was demonstrated roentgenologically. In one patient the examiner detected what he thought was an ulcer crater and it could not be confirmed histologically. Antral spasm resembling that seen in antral gastritis was found in 9 of the 29 patients examined. A localized incisura at the level of the involved area was present in 3 cases. Twenty-one patients showed a six-hour barium residue in the stomach. Some delay in emptying time occurred in 75 per cent of the cases, but it was considered to be of no significance in the differential diagnosis.

The roentgenologist's problem is differential diagnosis. He has no difficulty in deciding that a stomach is abnormal. It is possible in some instances to detect the development of cancer in an open peptic ulcer if the crater's rim and profile are studied. When cancer develops in a peptic ulcer, the mucosal folds stop at the edge of the cancer and do not extend into the ulcer. Under treatment, the crater of the healing peptic ulcer may diminish in size in all directions. The cancerous crater may diminish in depth but will diminish little or not at all in transverse diameter. Cancer of the mucosa or submucosa will cause muscle spasm of the stomach wall, but this spasm does not differ from that associated with inflammatory disease of the stomach wall. However, if spasm increases in length or degree while the patient is under observation, carcinoma should be suspected.

JAMES C. KATTERJOHN, M.D.

Cancer of the Stomach in Addison's Anaemia. W. A. Bourne. Brit. M. J. **1:** 92–94, Jan. 17, 1948.

Three cases of carcinoma of the stomach were discovered in 15 patients suffering with pernicious anemia. The abnormal changes in the stomach were observed by roentgen and gastroscopic examinations before any symptoms referable to the stomach had appeared.

Narrowing and some rigidity of the prepyloric antral walls were noted roentgenologically. Paleness and fixation of the gastric mucosa were seen gastroscopically. Surgical exploration in one of these cases was performed and the stomach appeared to be normal. It was not opened. Eighteen months later, severe gastric symptoms developed; at operation, a large polypoid carcinoma of the antrum with metastasis to regional nodes was found, and the patient died within a month.

The three case histories are submitted in detail, and it is concluded that gastric carcinoma is unduly frequent in patients with pernicious anemia. All the patients had been on liver extract therapy, and were in the older age group. The possibility of the carcinogenic effect of liver extract is noted.

Any abnormality of the antral portion of the stomach demonstrable roentgenologically should arouse strong suspicion of the presence of gastric carcinoma.

ALTON S. HANSEN, M.D.

Radiologic Study of Gastrectomies for Ulcer. H. Pons, Bru, and Andrieu. J. de radiol. et d'électrol. **28:** 457–462, 1947.

This paper is based on roentgenologic observations on more than 250 patients observed at periods varying from nine days to fourteen years after gastrectomy. In such examinations the following points should be noted: (1) extent of the resection; (2) type of anastomosis; (3) function of the anastomosis; (4) function of the gastro-intestinal tract as a whole; (5) presence or absence of postoperative lesions.

There are three stages in the evolution of the function of the stoma following gastrectomy: (1) Immediately following operation, the stomach empties poorly because of edema of the mucosa at the site of the anastomosis. (2) A second period follows, during which the stomach empties as soon as it is filled (dumping). (3) The third period is one of final adaptation, when the remaining portion of the stomach and the anastomosis acquire a certain degree of rhythm. The authors state that gastrectomies which do not function properly are rare. Failures are usually due to poor technic, particularly insufficient resection.

Two types of ulcers are seen following gastric resection: recurrent ulcers along the lesser curvature and marginal ulcers. The authors observed only two cases of recurrent ulcer. Marginal ulcers are very rare following adequate gastrectomy.

RODERICK L. TONDREAU, M.D.

On Roentgenological Diagnosis of "Jejunitis Acuta Phlegmonosa." O. W. Husebye. Acta radiol. **29:** 71–82, Jan. 31, 1948.

According to the author, jejunitis acuta phlegmonosa is a rare disease of the jejunum of non-specific origin. It has a tendency to gangrene, and the symptoms may simulate those due to perforated ulcer, acute appendicitis, or other abdominal emergency. Clinical diagnosis is difficult and seldom made.

Over a three-year period the author made a roentgenologic diagnosis of this condition in 14 cases. Two patients died after surgery and the diagnosis was verified histologically. Four other patients underwent surgery and in one of these cases resection was done.

The author first examines the patients without contrast media, in the supine position and standing, or lying on either side. Fluoroscopy is done to check diaphragmatic motion and intestinal movement if possible. The patients are then examined with the use of contrast media perorally.

Five cases are presented and illustrated. The roentgen findings are: (1) reduced diaphragmatic motion on one or both sides; (2) one or two distended loops of small intestine in the left upper quadrant; (3) fluid levels demonstrable in films made with the patient standing; (4) a roughly jagged relief of the jejunal mucous membrane with irregular circular folds of different height and appearance, partly sharp, partly blunt, and frequently a thickened intestinal wall; (5) gas in the colon; (6) adherence of the contrast material as a thin covering over the affected loops of small intestine.

The author feels that the roentgenologic diagnosis is sufficiently accurate that surgical intervention may sometimes be unnecessary. The patient is then treated with sulfa preparations and penicillin.

JOHN R. HODGSON, M.D.

Chronic Non-Specific Ulcerative Colitis: A Roentgenologic Study of Its Course. William E. Ricketts, Joseph B. Kirsner, and Walter Lincoln Palmer. Gastroenterology **10:** 1–15, January 1948.

This paper is based on a study of 156 cases of chronic non-specific ulcerative colitis in which the diagnosis was established by the presence of typical symptoms and proctoscopic findings. Roentgenologically an apparently normal picture was seen in 39 per cent of the series. But, though superficial mucosal changes may not always be demonstrable by roentgen examination, the procedure is valuable for visualization of the bowel beyond the area attainable with the sigmoidoscope and for following the course of the disease.

No good correlation between the extent of involvement of the bowel and the type of onset was demonstrated roentgenologically, and the relationship between the degree of involvement and the duration of symptoms was found to be inconstant. This latter observation is of particular interest in view of the general assumption that the extent and degree of involvement are a direct function of the duration of the disease.

In 46 patients of the series the course was followed roentgenologically for periods of two to sixteen years. The process remained stationary in 30 cases, evidence of progression was obtained in 11 cases, and in 5 marked improvement in the appearance of the colon was observed, indicating that a return to normal may occur even though the bowel has lost its haustrations and become narrowed and tube-like. Complications demonstrated by x-ray included polyposis, cancer, stricture, pseudopolyposis, and fistula.

Evidence suggests that in the majority of cases the disease attacks the colon either partially or completely during the initial episode and usually remains relatively stationary thereafter. Progression often consists of an increase in the severity of the changes in segments already involved, rather than continued retrograde extension of the process. The mortality rate is highest in the first one or two years of the disease.

Case reports are included, representative of chronic disease without roentgen manifestations, a progressive course, and regression. ALTON S. HANSEN, M.D.

Nonspecific Granuloma of the Colon. Louis T. Palumbo. J. Iowa State M. Soc. **38:** 6–9, January 1948.

Granulomas of the colon are briefly discussed and a case of solitary non-specific granuloma of the ascending colon is reported in detail.

A 51-year-old white man complained of loss of strength, weight, and appetite, frequent bouts of diarrhea and occasional bright blood in the stools over a period of eight months. More recently, severe abdominal cramps had developed. Physical examination showed slight temperature elevation and a sausage-shaped mass in the right lower abdominal quadrant, which was slightly tender. Occult blood was found in two of three stool examinations. The white blood cell count varied from 10,600 to 20,000 with 81 per cent polymorphonuclears.

Roentgen examination of the colon demonstrated a deformity with narrowing the lumen of the proximal portion of the ascending colon. Irregularity was more marked on the lateral wall of the bowel, and the deformity was best demonstrated in films made with compression. It was concluded that a definite lesion, inflammatory if not neoplastic, was present. Proctoscopic examination was negative.

At operation a firm, circumscribed mass was found on the posterolateral wall of the colon just above the cecum. Resection of the terminal 6 inches of ileum and the ascending colon was performed, and the postoperative course was uneventful. Pathological examination revealed a non-specific granuloma with ulceration.

It is pointed out that a filling defect or deformity in the colon, demonstrable roentgenographically, should call to mind the possibility of specific and non-specific granulomas in addition to carcinoma and sarcoma. The lesion is rare and the etiology is obscure. Surgical resection or some type of side-tracking operation, if the tumor is not resectable, is recommended. Biopsy should be done in any event for differentiation from carcinoma. ALTON S. HANSEN, M.D.

Liver Abscess. Thomas G. Hays, Robert B. Brown, and Ellwood W. Godfrey. U. S. Nav. M. Bull. **48:** 7–21, January–February 1948.

This article is a review of 10 cases of liver abscess seen on the surgical service of a naval hospital. Although *Endamoeba histolytica* was not demonstrated in all the cases, except when other cause could be found for the abscess it was undoubtedly amebic in origin. One case followed rupture of the appendix and was complicated by perforation of the diaphragm and a bronchial fistula.

With the return of the Armed Forces from various parts of the world where amebic dysentery is endemic, it is reasonable to expect an increase in incidence of the most common complication of amebiasis, namely, liver abscess. The insidious onset of the disease, the ease of transmission under supposedly good hygienic conditions, and the fact that persons may become carriers without exhibiting symptoms combine to make control difficult.

The diagnosis of liver abscess is, in many cases, a difficult one, and often rests primarily on a high index of clinical suspicion. The authors point out repeatedly that the clinical picture must lead one to suspect the diagnosis. The most important confirmatory evidence is gained through radiologic means. Elevation and fixation of the right dome of the diaphragm may be demonstrated by fluoroscopic examination and enlargement of the liver by further radiographic studies. [No mention is made of hepatosplenography. See Reeves and Youngstrom: Texas State J. Med. **42:** 310, 1946. Abst. in Radiology **49:** 255, 1947.]

One of the cases believed to be of amebic origin was complicated by a necrotizing abdominal wound infection which involved the muscles, skin, and subcutaneous tissue. This further emphasizes the histolytic nature of the organism responsible for amebiasis. Although the authors do not point this out, and it is seldom appreciated, it is the lysis of infected tissues which has led to the designation *Endamoeba histolytica*. (See Case 4, A. M. Snell: Clinical Problems of Amoebiasis, U. S. Nav. M. Bull. **46:** 1023, 1946.)

The authors repeatedly comment that perforation of the diaphragm and bronchial fistula may obscure the primary subdiaphragmatic lesion within the liver.

SYDNEY F. THOMAS, M.D.

Hepatic Amebiasis. Harold J. F. Kullman and Howard Golden. U. S. Nav. M. Bull. **48:** 22–30, January–February 1948.

The purpose of this paper is to call to the attention of physicians in the northern states the importance of watching for amebic carriers with or without mild symptoms and treating them intelligently. This is necessary for reduction of the incidence of hepatic amebiasis, since it is not yet known what "sets off" the process which results in hepatic involvement.

As used by the authors, the term "hepatic amebiasis" covers both amebic hepatitis and amebic abscess of the liver. Both clinically and radiologically diagnosis is difficult. Stool examination and proctoscopy are often fruitless. Snell is quoted as saying that "for every case in which diagnosis is made by finding *E. histolytica* in the stools, there is one case in which the diagnosis is made by observing the therapeutic effect of emetine" (U. S. Nav. M. Bull. **46:** 1023, 1946). Radiologic findings are helpful in only about half the cases. One is limited to indirect signs relative to the right half of the diaphragm and the right lower lung field. These are produced by generalized upward enlargement of the liver or localized bulging, extension through the diaphragm producing amebic pleuritis and later pleuropulmonary amebiasis, usually with abscess formation. Presence of gas in an abscess cavity of the liver is a helpful sign, but it occurs late and is indicative of secondary infection. Calcific changes in the encysted abscess wall are also of late occurrence. They are rarely encountered and are of little value in acute and subacute amebiasis.

The treatment of the disease is gone into in some detail, and some individual cases are carefully presented, with the treatment schedules graphically outlined in clear-cut fashion. These should be studied in the original rather than abstracted. In their summary, the authors point out that one must not continue too long in hope of obtaining a positive stool or proctoscopic verification of the disease. When penicillin therapy fails or produces only a partial result, because of the presence of secondary invaders, a therapeutic trial of anti-amebic chemicals should be made.

SYDNEY F. THOMAS, M.D.

Visualization of the Rokitansky-Aschoff Sinuses of the Gallbladder During Cholecystography. Herman C. March. Am. J. Roentgenol. **59:** 197–203, February 1948.

When the Rokitansky-Aschoff sinuses are demonstrated on the cholecystogram, a unique and characteristic picture is produced. A fine opaque rim surrounds the gallbladder shadow just outside a line of increased radiolucency. The opaque rim is thought to be due to filling of the sinuses with the gallbladder dye. A healthy gallbladder rarely shows the presence of Rokitansky-Aschoff sinuses. The gallbladders in which they are demonstrable usually show thickening by an infiltration of inflammatory cells in the subepithelial layer and the perimuscularis, as well as connective-tissue proliferation and some edema; in other words, evidence of chronic cholecystitis. Since many diseased gallbladders are not visualized at all, Rokitansky-Aschoff sinuses are not frequently seen on the cholecystogram. Their anatomy and the mechanism of their production are discussed.

A case is reported in which the cholecystogram showed the characteristic picture described above. The patient had a stricture in the body of the gallbladder, believed to be congenital. The lower part of the organ was markedly thickened and it was in this region that the sinuses were demonstrable.

JAMES C. KATTERJOHN, M.D.

Penetrating Wounds of the Abdomen. M. Slater. Am. J. Roentgenol. **59:** 168–176, February 1948.

Routine anteroposterior and lateral roentgenograms are of little value in completely evaluating penetrating wounds of the abdomen. Little or no information can be obtained regarding the presence of small amounts of air in the peritoneal cavity if only the routine views are employed, and many times erroneous deductions are made after demonstrating opaque foreign bodies.

In the identification of pneumoperitoneum the following positions have been suggested: (1) anteroposterior or postero-anterior roentgenograms with the patient in the erect or sitting position, (2) the same projections with the patient in the left lateral decubitus position, and (3) the use of a horizontal beam with the patient recumbent. While most radiologists feel that the procedures above are listed in the order of preference, the author's experience in a series of 600 patients examined in World War II indicates that examination by a horizontal beam with the patient recumbent is the procedure of choice. Air was demonstrated in about half of the 600 patients examined, and in all but two there was surgical confirmation of the intraperitoneal injury. About 10 per cent of the patients in whom free peritoneal air was not demonstrated were operated upon. This group was composed of patients with old injuries and with peritonitis. Presumably the free air had been absorbed.

In many patients examinations were performed by both the author's recommended technic and with the patient in the sitting position. These combined studies indicated that the use of the horizontal beam was superior to the other procedures.

It is believed by the author that pneumoperitoneum is occasionally encountered when the intestines have not been perforated and that air can be introduced into the peritoneal space with the missile. In general, more air is found in those patients who have associated diaphragmatic injury. JAMES C. KATTERJOHN, M.D.

THE SPLEEN

A Case of Cyst of the Spleen. E. V. Barling and John Borrie. Brit. J. Surg. **35:** 328–330, January 1948.

A girl aged 17 was admitted to the hospital with a diagnosis of left hypernephroma. There was a large smooth tumor on the left side extending from the costal margin down as far as the umbilicus. Intravenous pyelography showed doubtful compression of the left upper calices. A diagnosis of cyst of the spleen was made by a combined barium enema study and retrograde pyelography. This revealed a normal left renal pelvis but there was downward displacement of the splenic flexure and left kidney. At operation a large cyst of the spleen was found, containing altered blood and cholesterol crystals. Following splenectomy the patient made an uneventful recovery. MAX CLIMAN, M.D.

THE MUSCULOSKELETAL SYSTEM

Rheumatism and Arthritis. Review of American and English Literature of Recent Years. (Ninth Rheumatism Review.) Philip S. Hench, Chairman, Editorial Committee, *et al.* Ann. Int. Med. **28:** 66–168, 309–451, 1948.

This comprehensive review of the English and American literature on rheumatism and arthritis prepared by the Editorial Committee of the American Rheumatism Association, covers the years 1941–45. The bibliography lists 1995 contributions and twelve books. The papers of principal interest to radiologists have for the most part been abstracted in RADIOLOGY.

Minor Fractures of the Cervical Laminae Simulating Ruptured Cervical Disk. Report of Two Cases. Frederic V. Kristoff and Henry M. Dratz. J. Neurosurg. **5:** 95–98, January 1948.

Two cases of laminar fractures of the cervical vertebrae, occurring near the intervertebral foramina and complicated by root compression, are reported. The close resemblance of the clinical picture to that of a ruptured cervical disk is emphasized. Roentgenograms are necessary to disclose the true nature of the condition. Stereoscopic views of the neck should be obtained—the anteroposterior, the lateral, and both oblique exposures—in order to get better visualization of detail. Plain oblique views, taken of both sides for comparison, may, however, be of great aid in directing the surgical approach by showing distinctly either a small bone fragment protruding into the intervertebral foramen in question or a unilateral disfiguration of the same. Myelography is unnecessary if the plain roentgenograms are carefully made. The myelogram may, or may not, show a filling defect in the contrast shadow; it gives no lead as to etiology.

Surgical treatment is the only proper way of handling these lesions, and operation should be performed as soon as diagnosis has been made.

Roentgenograms are reproduced.

Radiographic Study of Fractures of the Carpal Navicular Bone. John L. Enyart, Harry J. Brown, and Jack B. Trunnell. U. S. Nav. M. Bull. **48:** 66–68, January–February 1948.

An analysis is made, from the radiological point of view, of 52 cases of fracture of the carpal navicular bone.

In 17 cases fluoroscopy was done in an attempt to correlate the amount of motion possible within a cast made up in various shapes and with various amounts of padding. On the basis of these observations, two recommendations are considered admissible:

(1) All patients giving a history of force having been applied to the palm of the dorsiflexed hand, particularly those with evidence of sprain or fracture, however slight, and especially with tenderness in the anatomical snuff box, should be placed in a cast, even though there is no x-ray evidence of fracture. The conventional position of dorsiflexion, radial deviation and abduction of the thumb should be employed. After a two-week period, a repeat x-ray examination will almost certainly disclose a fracture if it is present. If not, the cast may be removed and no harm will have been done. On the other hand, in the case of fracture, the promptest and best possible treatment will have been instituted.

(2) Casts applied for the treatment of fractures of the navicular bone should be of the skin-tight variety. That is, no stockinet should be used and the felt padding should be limited to the prominences over the dorsal portions of the radius and ulna. The terminal phalanx of the thumb should not be entirely encased, but should be sufficiently incorporated in the cast to prevent any motion. The distal end of the cast should extend about 1 cm. beyond the ends of the metacarpal bones. Proximally, the cast should extend to the elbow, but need not include it, though there is some evidence that prevention of pronation and supination would be desirable.

SYDNEY F. THOMAS, M.D.

Tear of the Lateral Ligament of the Ankle. Louis A. Goldstein. New York State J. Med. **48:** 199–201, Jan. 15, 1948.

A warning is sounded that, in the more severe sprains of the ankle, complete rupture of the lateral ligaments of the joint must be suspected. A negative routine roentgenographic examination in such an instance does not rule out serious injury. If in routine anteroposterior and lateral roentgenograms there is no evidence of fracture or mortise spread and if the clinical examination reveals lateral ligament tenderness of definite or questionable significance, radiographs are made under inversion stress, the uninjured ankle being also examined under stress for comparison.

The normal ankle under inversion stress will show less than a 10-degree talar tilt. Incomplete tear of the lateral ligament allows a 15- to 20-degree talar tilt. With complete tear of the lateral ligament and the lateral joint capsule a tilt of 30 degrees or more will be present. The x-ray examinations are made with the foot in maximum inversion and the knee in a true anteroposterior plane, with the patient under sodium pentothal anesthesia.

Complete tear of the lateral ligament of the ankle requires prolonged immobilization in a plaster cast. Undiagnosed and untreated ligament tears may result in unstable ankles. EDWARD E. LEVINE, M.D.

Two Synovial Fibrosarcomas (Jönsson). Folke Knutsson. Acta radiol. **29:** 4–6, Jan. 31, 1948.

Points Regarding Synovial Fibrosarcoma. Gunnar Jönsson. Acta radiol. **29:** 356–357, April 30, 1948.

Knutsson presents the classification devised by Jönsson of malignant tumors of joint capsules, tendon sheaths, and bursas. He recognizes two groups: synovialoma and synovial fibrosarcoma. The synovialomas are more malignant and often metastasize to the regional lymph nodes, lungs, and other internal organs. They respond to roentgen therapy.

The fibrosarcomas sometimes contain calcium, are often incorrectly diagnosed as inflammatory lesions, and present a characteristic extreme tenderness on examination. It is stated that they seldom metastasize to the lungs and other internal organs, but again there is a risk of local recurrence and distant metastasis.

Two cases of synovial fibrosarcoma are included, with illustrations depicting the "sharp-edged shards of calcification which proved they were a part of the tumor structure."

Jönsson's paper is a comment on that of Knutsson, calling attention to some misunderstandings on the part of the latter author. According to Jönsson, metastasis is not uncommon in synovial fibrosarcomas, having been demonstrated in 3 of his 8 cases, and their prognosis, though it appears to be somewhat better than for synovialoma, must still be regarded as very serious. Mention is made of the characteristic calcific changes sometimes seen in synovial fibrosarcoma, to which Knutsson called attention. Jönsson himself included such a case in his monograph on soft-tissue tumors (Acta radiol. Suppl. XXXVI, 1938).

JOHN R. HODGSON, M.D.

THE GENITO-URINARY SYSTEM

On Pyelogenic Cysts. Harry Holm. Acta radiol. **29:** 87–94, Jan. 31, 1948.

Pyelogenic renal cysts form a well defined group of solitary renal cysts. They are derived from the wolffian duct system. These cysts are generally small, round, sharply defined cavities, with walls of the same construction as the wall of the renal pelvis. They are usually connected with the renal pelvis by a canal, which may be fairly wide or may be partially or completely obliterated. When the communication is obliterated, the contents of the cyst may consist of viscid material containing considerable calcium. There is a strong tendency to the formation of calculi in the cysts.

Pyelogenic cysts are not uncommon. Thirty cases were seen in the Oslo Municipal Hospital over a three-year period, and calculi were found in half of them. Five cases are presented with illustrative roentgenograms. JOHN R. HODGSON, M.D.

Proteinuria and Kidney Injury Among Workmen Exposed to Cadmium and Nickel Dust. Preliminary Report. Lars Friberg. J. Indust. Hyg. & Toxicol. **30:** 32–36, January 1948.

Examination of 19 workmen (in Sweden) who had been exposed to cadmium and nickel dust for more than eight years revealed proteinuria in all but one. No proteinuria was found among 19 men who had been similarly exposed for a year or two only. In 14 cases, there was impaired kidney function. Polarographic examination of the blood of 8 workers with proteinuria showed pathologic changes in all. Further investigations brought to light impaired lung function in the workers with the longer employment. Examinations with a spirometer revealed that 15 of the 17 men examined suffered from emphysema. In only 4 were these changes demonstrated roentgenologically. In 6 patients x-ray examination revealed signs of inactive pulmonary tuberculosis, and in one patient, active tuberculosis.

Concealed Diverticulum of the Male Urethra as a Cause of Urinary Obstruction. Robert E. Gross and Alexander H. Bill, Jr. Pediatrics **1**: 44–51, January 1948.

Three cases of urinary obstruction by concealed diverticula of the urethra are presented. The patients were five years, two years, and nine months of age, respectively. In the first two patients, the urethral abnormality was unrecognized during life, and the boys died from the effects of obstruction, urinary tract infection, and uremia. In the third child the cause of the obstruction was found by roentgenologic visualization of the urethra and surgical relief was promptly instituted.

The correct diagnosis should be suggested when there is evidence of urethral obstruction which cannot be explained satisfactorily on some other basis. The insertion of sounds or catheters through the urethra toward the bladder will not reveal the abnormality, because they slide over the roof-like flap which partially covers the diverticulum. Such instrumentation should always be attempted when searching for a urethral obstruction, but the free passage of an instrument serves only to exclude a urethral stenosis. Endoscopy may be of some value, but may be difficult or impossible in the very young patient. Urethrography offers the best means of examining the urethra and detecting a hidden diverticulum. It is preferable to make such studies with a water-soluble material and to use a solution of great radio-opacity. Viscorayopaque or 35 per cent diodrast is quite satisfactory.

The child should be placed with his back in an oblique position (with respect to the film), with the leg away from the film in extension, and the other leg drawn up in flexion. This position prevents the obscuring of any part of the urethra by an overlying bone. The syringe should be fitted with an acorn-shaped rubber tip which can be pressed snugly into the urethral meatus. The film should be exposed while the iodide solution is being injected.

Cure of urethral obstruction in these cases can be quickly accomplished by removal of the flap-like roof of the diverticulum, as it is the ballooning up of this roof, when the diverticulum is filled with urine, which causes the obstruction. It is not desirable to remove the diverticulum itself.

THE BLOOD VESSELS

Arteriography in Cases of Aneurysm and Arteriovenous Fistula: with a Review of the Literature Concerning Choice of Solution. Harris B. Shumacker, Jr., and Anne F. Godley. Yale J. Biol. & Med. **20**: 273–289, January 1948.

The authors' experience with arteriography was obtained from its performance in selected cases during the study and treatment of approximately 300 aneurysms and fistulas. They used 70 per cent diodrast after testing the patient for sensitivity by a drop of the solution on the conjunctiva. For cerebral arteriography, 5 to 10 c.c. were injected into the internal carotid and for the major arteries of the extremities 15 to 25 c.c. were used. Injection into the internal carotid is best accomplished under local anesthesia, by operative exposure of the vessel just beyond the bifurcation of the common carotid. Under such circumstances, injection is carried out during transient proximal occlusion of the artery by means of a rubber-shod clamp or by traction upon a tape placed around the vessel. Similarly, injection into the arteries of the extremities can sometimes be made during proximal digital occlusion provided the compression does not interfere with accurate maintenance of the needle tip within the lumen.

Before the injection is made, a scout film is exposed and developed in order to make certain that the technic is satisfactory and to have a control film for comparison. If the injection is made with the artery occluded, a second arteriogram is taken as the last of the solution is delivered into the artery. The compression is then released and a third film is exposed immediately. A fourth exposure is often made a few seconds later. Frequently, several exposures are made in as rapid succession as possible during the injection and immediately after the completion of injection. This is done because the opaque medium sometimes remains in an aneurysmal sac for a few seconds after it has actually disappeared from the arterial tree. The authors feel that a number 19 needle is sufficiently large. The arterial puncture is relatively painless, especially if it is preceded by a procaine infiltration of the skin and subcutaneous and periarterial tissues.

Arteriography is rarely necessary to establish or rule out the diagnosis of peripheral aneurysms or fistulas. It has an important role, however, in the diagnosis of intracranial aneurysms and perhaps occasionally for intrathoracic or intra-abdominal aneurysms. While intracranial aneurysms usually present characteristic symptoms, an exact diagnosis by arteriography is advisable before ligation of the internal carotid, particularly in view of the possible sequelae of this procedure. Localization of an aneurysm or arteriovenous fistula may be equally important as its diagnosis and may prove a valuable aid to the surgeon in his operative approach. "Certainly," say the authors, "arteriography should be carried out in cases with inadequate collateral circulation in which the clinical signs point to involvement of a major artery and in which there is a possibility that the lesion actually involves a neighboring vessel of relatively little importance in the nutrition of the extremity."

The authors point out that sympathectomy may produce a "cure" of an aneurysm by thrombosis and they have observed some 13 such instances. Generally the course of events under these circumstances is evident enough. Sometimes, however, the progress is not entirely clear, and in these cases arteriography may be of considerable help in determining proper treatment and disposition.

The choice of solutions takes up the greater part of the article and anyone interested in the subject should read it *in toto*. All too frequently the injection of iodine compounds has been found to produce arterial spasm with resultant ischemia. Dilatation may occur for a short time, only to be followed by spasm, and where a limb might be thus jeopardized the authors believe that thorotrast should be used. The comparative merits of this medium and diodrast are discussed at length. Diodrast has the advantage that it is not radioactive and that it is rapidly excreted in the urine. It does not, however, provide as clear-cut shadows as thorotrast except in the case of the aorta, where it mixes with the blood more readily. Reactions may follow the use of either medium, and these are reviewed in detail.

The most serious drawback to the employment of thorotrast is its radioactivity and its accumulation in the reticulo-endothelial system. Thorium itself has a

half life of 1.31×10^{10} years, but it breaks down into mesothorium, radiothorium, thorium X, thoron, thorium A, thorium B, and thorium C, with half lives ranging from a few seconds to seven years. Mesothorium is thought to be of chief concern because its radioactivity increases over a period of twenty-five years, while that of thorium and radiothorium decreases. The total radioactivity of thorotrast, therefore, decreases for the first five years, reaching a low of 50 per cent and then increases. Of the rays emitted, the alpha rays are the most active biologically (though fortunately, they are not very penetrating). It is estimated that 25 c.c. of thorotrast give off an amount of alpha rays equivalent to that given off by 0.5 to 1 microgram of radium. The same quantity of thorotrast gives off an amount of gamma rays equivalent to that from 0.3 to 0.4 microgram of radium.

Experimentally thorotrast has been shown by some workers to be carcinogenic, but others have failed to demonstrate such an effect. A single case has been found in the literature in which a malignant tumor—an endothelial-cell sarcoma of the liver—arose adjacent to a large accumulation of thorotrast.

The authors' own preference is 70 per cent diodrast except in those instances in which a satisfactory arteriogram can be obtained with only a few cubic centimeters of solution and in cases in which there appears to be particular hazard of ischemic difficulty from vasoconstriction. SYDNEY F. THOMAS, M.D.

TECHNIC

Stereo Screen Photography. Tauno O. Mannila. Acta radiol. **29:** 65–70, Jan. 31, 1948.

Screen photography has been rather widely used for mass survey studies of the chest. The author describes a method of stereo screen photography applicable to any part of the body, which becomes practical only when the screen-focus distance is reduced and when the distance between camera and screen is likewise reduced. A formula is developed for the determination of the distance between the focuses in the two stereograms and a method for obtaining stereoscopic projections of a screen photograph is presented. The technical factors used are given.

The small stereo photographs made on cine-film are examined by means of stereo binoculars with magnification. The method is economical and has proved practical for the localization of splinters and fracture fragments. JOHN R. HODGSON, M.D.

Technical Improvements in Cerebral Angiography. Arne Engeset and Hans Kvadsheim. Acta radiol. **29:** 83–86, Jan. 31, 1948.

In 1937 Zehnder (Zentralbl. f. Neurochir. **2:** 281, 1938) described an electric contact attachment to the syringe used in angiography which turned on the roentgen rays at any given position of the piston, ensuring exact timing and dosage of contrast material. The authors have adopted this idea and elaborated on it by adding another electric contact and a timer to produce an exposure at any given time following the original arteriogram. Thus it is possible to obtain phlebograms at any time from one to ten seconds after the arteriogram.

This procedure has been used on more than 100 patients and it has proved to be very satisfactory.
JOHN R. HODGSON, M.D.

A Simple and Inexpensive Laminograph for Use in Neurosurgery. William Beecher Scoville and Gerhard Danelius. J. Neurosurg. **5:** 101–103, January 1948.

A simple and inexpensive laminograph for use in neurosurgery, which is adaptable to any standard x-ray table, is described. A line drawing presents the details of construction. Comparative illustrations of the 3rd and 4th cerebral ventricular systems with and without the use of the laminograph are reproduced.

RADIOTHERAPY

Tuberculous Adenopathy and Its Roentgen Therapy. Alfonso C. Frangella and Naúm Yasky. Prensa méd. argent. **35:** 26–30, Jan. 2, 1948.

The authors have employed both radium and roentgen rays for tuberculous adenopathy, but after treating 31 out of 159 cases by radium, they now prefer roentgen therapy. Of this series of 159 cases, 100 were treated by roentgen rays, 31 by radium, 10 by roentgen rays and phototherapy, 5 by roentgen and radium therapy combined, and 7 by phototherapy alone. In 6 the method was not specified. The results were as follows: clinical cure in 38, or 24 per cent; frank improvement in 60, or 38 per cent; some improvement in 11; no improvement in 7. In 43 cases the outcome is not specified, but no case appears to have been made worse by the treatment. In the cured cases, the lesions underwent fibrous evolution and, in most cases, eventual calcification.

The time required for roentgen therapy is given for 31 cases. It ranged in this group from less than a month to six months. The total dosage in a series of 68 cases was as follows: 200 to 500 r in 11 cases; 600 to 1,000 r in 11 cases; 1,100 to 1,500 r in 21 cases; 1,600 to 2,000 r in 9 cases; 2,100 to 3,000 r in 9 cases; 3,100 to 4,000 r in 4 cases; more than 4,000 r in 3 cases.

In forms associated with tumefaction the dosage is low (50 r per treatment), while high dosage is required for lesions of the scrofulous type. These latter forms have been treated by the Holfelder technic—100 r in a single session, and then, if there is no unfavorable reaction (increase of swelling or pain), 420 to 440 r (this last dose, however, having been used but rarely).

In the lymphomatous type of the disease, the dose may be spread over a considerable period. This form is benefited by almost any amount of radiation. The authors began with 50 r weekly, slowly increasing to 350 r per session. The total dosage varies between 200 and 6,000 r and the time of treatment from a single session in one day to a three-year period (in one case with recurrence and extension treatment was prolonged over five years).

In very extensive lesions with involvement of the skin, superficial irradiation is given over an area of 150 sq. cm., beginning with 50 r and increasing to 350 r to each focus, if there is no reaction. When there is definite fluctuation, indicating the presence of pus, the latter is evacuated by puncture. If fistulae occur, they heal without any increase in the dose.
JAMES T. CASE, M.D.

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